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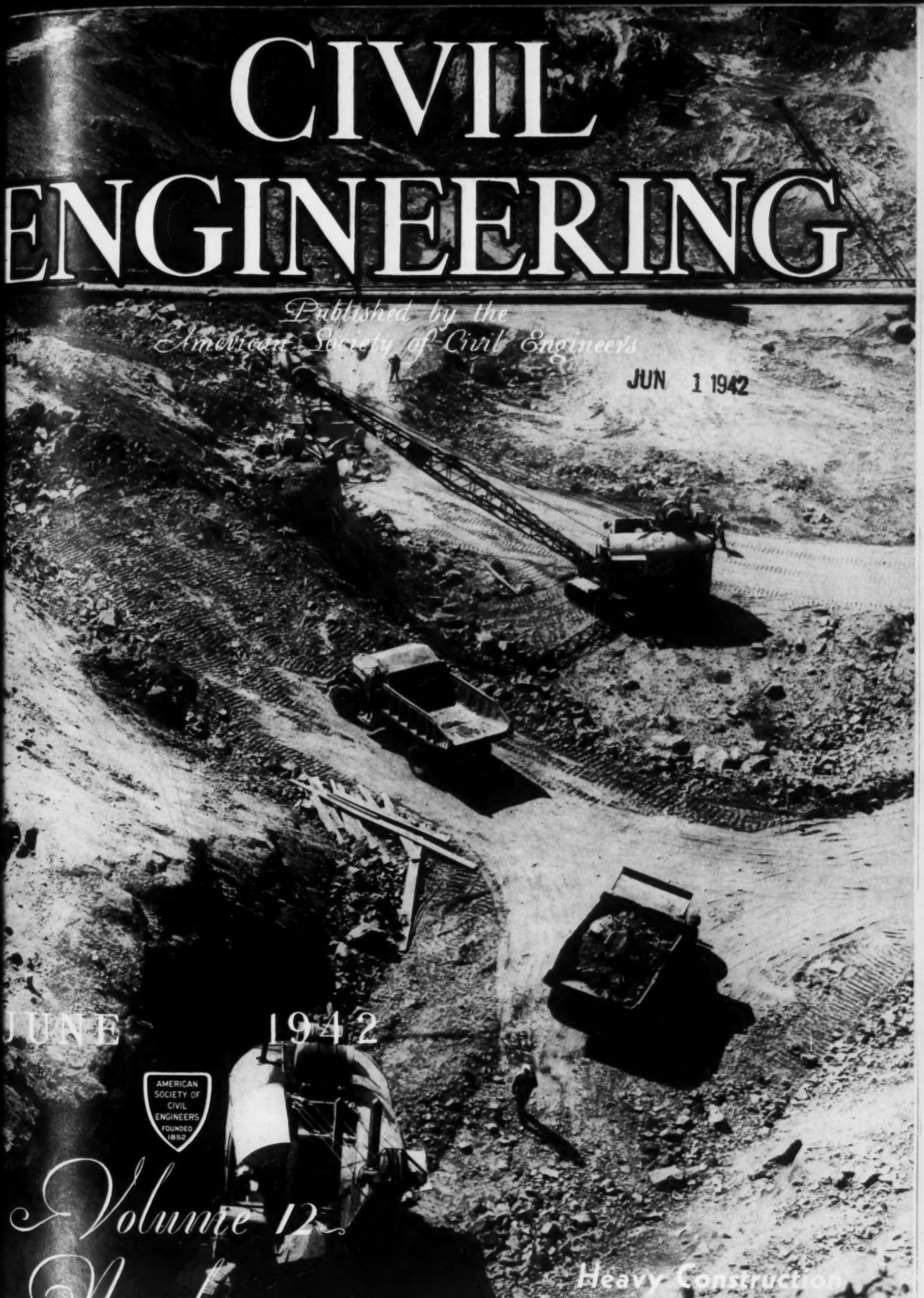

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AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

Volume 12
Number 6

Heavy Construction Equipment

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This Is an Engineers' War

Address Before a Luncheon Gathering at the Spring Meeting of the Society in Roanoke, Va., on April 23, 1942

By EUGENE REYBOLD, M. AM. SOC. C.E.

MAJOR GENERAL, CORPS OF ENGINEERS, U.S. ARMY; CHIEF OF ENGINEERS, WASHINGTON, D.C.

NO better evidence of what we are fighting for in this great global war could be found than this very meeting amid the rare beauties of the Blue Ridge Mountains. To me, the occasion is inspiring. Here we are—members of a free American institution, meeting in a free American city, in the free and untrammeled American way. Certainly these things are worth fighting for.

Uppermost in Our Minds.—In common with all Americans, we engineers today have our thoughts centered on this war for our very existence. The first thought of every real American is: "How can I do my part toward bringing about the final victory?"

The winning of the war is indeed a job for all Americans. We are engaged in the greatest team effort of history. The resources of a continent and the efforts of 140,000,000 people are joined with the single aim of putting an invincible American fighting force in the field. By "in the field" I mean to include the ground, the air, the seas. The invincible American fighting force now being created will number several millions of soldiers, sailors, airmen. But, in fact, that force will be but the sharp edge of the sword wielded by the strong hands of the whole American nation.

No Group Deserves Special Mention.—Like everyone else, we engineers are simply members of the all-American team. Our part, however, is very big and very important. Generally speaking, the works of engineers underlie the entire war effort in all its aspects and phases. Therefore, to discuss in detail the works of engineers in war would be to discuss in detail all phases and aspects of our present effort.

In the past months we Americans often have had occasion to lament our failure to prepare adequately for a war which has plainly been in the making in the hearts of the dictators for the past ten years. All too frequently we have heard the phrase "too little and too late." But, in a larger sense, our situation is not, and never has been, fundamentally black. For deep down beneath the surface there has always been the solid fact of America's industrial potential. We were not prepared for war in the way of having thousands of airplanes and tanks on hand and millions of men standing under arms. We were prepared in the fundamental way of having a numerous liberty-loving people, a rich country, and an industry capable of being adapted to war production on a scale such as the world has never yet seen.

America can thank its engineering profession for many of these fundamental assets with which we enter the war. For American industry is largely the product of American engineering genius.

A Specific Case.—When our President speaks of an air force totaling 200,000 planes, America responds with confidence. That confidence is engendered from the knowledge that American engineers can build the necessary plants, produce the necessary tools, and adapt American methods of mass production to the task at hand. When it is announced that our light tank production is already outstripping that of Germany, or that we are producing gun barrels at fantastic rates through use of revolutionary processes, no American is surprised. America knows that its engineers are up to any task. And America knows that for every such item actually published, there are many which must be held secret for military purposes.

Recently I was present in a western city when a great bomber assembly plant was formally completed. The size of this plant, and its capacity in bombers per day, is something to excite the imagination. Exactly one year before, the ground on the site of the plant had first been broken. During that single year, the plant was designed, the plans and specifications drawn, the contracts let, the tools and equipment produced, and the construction completed. As I saw the first bomber roll off the assembly line, it seemed that the reverses of these first few months of war emerged in clearer perspective. They emerged as setbacks—bitter indeed, but only temporary—and due to be redeemed one day in overwhelming measure. We may be sure that the generals in Tokyo are not jubilant over present events but that they soberly regard the implications of just such things as the opening of that bomber plant.

Engineers Close to Combat.—Speaking of the Corps of Engineers of the Army, it is convenient to consider, first, the engineers directly connected with combat, and second, those engaged in construction. This is a classifi-

cation for convenience only. All of our engineers, in uniform and out, at the front and at home, are engaged directly in the winning of the war.

On the battlefield of today, the premium is on mobility. The tank and the plane are the modern weapons of decision. The mobility of modern war arises fundamentally from the development of the gasoline engine. However the vehicles powered by the gasoline engine depend in turn on routes of communication—and, in the case of the plane, on landing fields and bases. Routes of communication and air bases are the products of engineers. This fact is recognized in the doctrines of all modern armies. It is evidenced in the statement frequently made that "This is an engineers' war."

Those Engaged in Construction.—In the field of construction, the impact of this war has been enormous. Definite figures may not be given; but anyone who has traveled around the country in recent months has seen evidences of our work, in the form of new cantonments, new air bases, and new factories. Measured prosaically in dollars, our program exceeds in cost the total national budget of a few years ago. The number of men employed on our works would make a sizable army, even as modern armies go.

In this vast construction program, the Corps of Engineers has leaned heavily upon the professional engineers of the country. In many cases, professional engineers have dropped their normal duties and have come to us as commissioned officers. In many other cases, the relationship has been on a consulting or contractual basis. But whether in uniform or not, the engineers of the country have heeded our call.

Engineers Rise to the Occasion.—Let no one get the impression that this construction program of ours is a simple case of "engineering as usual." The contrary is the case—and emphatically so. Most of our construction has been in the face of time deadlines which would have seemed impossible in normal times. We have operated under priorities in materials. We have cut corners wherever possible. In fact, we have conducted this great construction program under conditions which approach those of the combat engineer who is working close to the front. We have done just as that front-line engineer must do: we have made the best of the means at hand, and we have finished the jobs on time.

Let no one think, either, that the professional engineers who work in our organization and at our side are free from personal hardships, dangers, and sacrifices. From the very start, the practicing engineers of the country on whom we have called have been willing to go wherever necessary and to do whatever is necessary. They have adapted themselves to the situation like the soldiers they are.

For Instance, the Alaska Road.—Just recently we have had stirring examples of what I have in mind. All of you have read of the highway which even now is being pushed through to our vital bases in Alaska. Here is a project to be compared with the great pioneer engineering feats of all times. This Alaskan road extends more than 1,500 miles, across wilds and wildernesses, over great rivers and muskeg bogs, through canyons and across mountains. Were it not dwarfed by current war reports, the construction of the Alaskan Highway would be universal front-page news.

The general scheme under which the Alaskan road is being built itself indicates the cooperation existing between military and civilian engineers. We of the military are pushing through the pilot pioneer roads; we are providing a route that will be passable, and will serve the immediate pressing military purposes. Behind us will then come civilian contractors, working with us and with the Bureau of Public Roads; they will convert the rough pioneer road into a modern highway. The resulting road will play a vital role in our war effort; and in later years the highway will serve equally well the needs of peace.

Rôle of Construction Regiments.—For our pioneer work on this Alaskan road we have called on existing engineer units—particularly those that are equipped and trained for general pioneer construction work. But we are also using certain of our special units—such as topographic battalions and ponton companies. As with all other engineer units, these are officered largely by men who a few months ago were practicing the profession of civil engineering.

The same is true of the new "construction regiments" recently created. These also are officered almost completely by engineers drawn from the civilian construction industry. After initial training in military fundamentals, the construction regiments will be available for assignment here or in any of the several theaters of war, for important special construction jobs. This represents a significant development—just as did the creation, more than a year and a half ago, of our special aviation-construction units.

Not Blind Confidence.—In a brief and generalized talk, there is a tendency to dwell on the favorable aspects of things and to pass quickly over the unfavorable ones. My aim is to leave with you a feeling of confidence in the ultimate victory—but at the same time to deflate any false optimism.

It is the Americans—the people themselves—who must do the actual fighting. Tanks and planes and guns are only means to an end. When the Japanese generals look with alarm on our growing output of arms, their alarm arises from the knowledge that these arms are going to be wielded by men who are spiritually prepared to fight the war through to victory! What really alarms the Axis lords of war is the thought of the spirit of Bataan, coupled with the industrial potential which even now is blossoming into full strength.

A Noble Heritage.—And as for us, we must understand that our enemies, too, are prepared to fight to the last. There will be no parade to victory in this war. The victory will come—but only after the people of our great nation have plumbed the depths of sorrow and sacrifice.

Here in Virginia two hundred-odd years ago, there stood a homely log stockade. It was manned by half a hundred hardy pioneers. It was all that stood between the pioneer families and the savage Indians. Before their civilization was finally established, before they could till their fields in peace, those pioneers had spilled their blood on many a nameless field. But their spirit was strong and their aim was true—and so a great nation took root on this continent.

There is an analogy here, I think, which none can fail to grasp. What the blood of our fathers has given us, we will, by our own blood, retain.

E. B. BLACK
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NUMBER 6

Model Study of Tidal Currents in East River, New York

By L. S. DILLON, M. AM. SOC. C.E.
LIEUTENANT COLONEL, CORPS OF ENGINEERS, U.S. ARMY, DISTRICT ENGINEER, NEW YORK, N.Y.

AS its name implies, Hell Gate is a byword for difficult navigation. In spite of much outlay, this short stretch in the East River along Manhattan Island is still a hazard. The problem is only intensified by the concentrated water traffic. But it is in process of being solved, as Colonel Dillon explains here. By means of a large model, some twenty independent schemes were tested. The final result, he states, gave reasonable solutions for current alinement and velocity. At the same time it was economical, as much less property at Hallets Point had to be bought, and much less excavation was required. This paper originally was presented before the Waterways Division at the Society's Annual Meeting in January.

A MODEL study of tidal currents in the East River, New York, was made as a result of the desire to provide safe navigation and to increase the available depth for ships passing from New York Harbor to Long Island Sound. Because of adverse tidal and current conditions, principally in the vicinity of Hell Gate and Belmont Island, a model study by the U.S. Waterways Experiment Station at Vicksburg, Miss., was considered the best method of determining the most effective and economical plan.

The East River (Fig. 1) is a tidal strait 16½ miles long and from 600 to 4,000 ft wide, connecting the Upper Bay of New York Harbor at the Battery, New York, with the western end of Long Island Sound at Throgs Neck. From the standpoint of navigation, most important is the 1.2-mile stretch known as Hell Gate, where a promontory, Hallets Point, forms a sharp bend in the river.

ACTIVE WATERWAYS

From the Battery to Clason Point, 13.4 miles, there are over 300 piers, wharves, ferry slips, and car-float bridges. The waterway is spanned by seven large bridges with vertical clearances of from 132 to 140 ft.

The East River is one of the busiest commercial arteries of New York Harbor. For the 10-year period 1931 to 1940, the annual commerce averaged about 50,400,000 tons. The highest annual total during this period was in 1940, when more than 60,600,000 tons of commodities and 35,800,000 passengers were moved over the waterway.

During 1940 a total of 245,710 vessel trips were made into and out of the East River, and of this number 43% were loaded to drafts of between 22 and 32 ft. Numerous coastwise vessels plying between New York and New England move through this waterway. There is also a considerable amount of local traffic, consisting of passenger ferries, car ferries, tows, tankers, sand and gravel barges, and other small harbor craft, which move continuously in all directions on the river.

The controlling mean low-water depth from deep water in the Upper Bay to the Brooklyn Navy Yard is 40 ft, except for a small section opposite the Battery, where the limiting depth is 39 ft. From the Navy Yard through the West Channel at Welfare Island and Hell Gate to Throgs Neck, the controlling mean low-water depth is 35 ft for widths varying from 550 to 1,000 ft.

Difficulties attending navigation in the East River are due to congestion of traffic and to sharp curves, lack of sufficient width, and strong, irregular currents. The mean range of the tides varies according to locality; it is

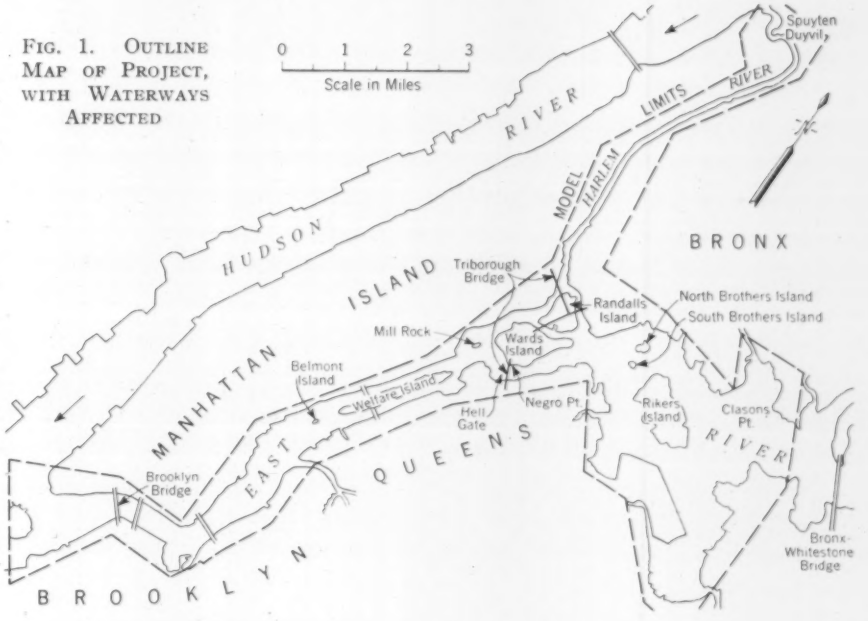


FIG. 1. OUTLINE MAP OF PROJECT, WITH WATERWAYS AFFECTED

4.4 ft at the Battery, 5.1 ft at Hallets Point, and 7.1 ft at Throgs Neck. The tidal movement in the East River is decidedly different from that in a true tidal river with one entrance, like the Hudson for example. It is the result of two tide waves, one entering from the Upper Bay at the Battery and the other from Long Island Sound at Throgs Neck. The tidal phenomenon is essentially hydraulic in character, brought about by these two

FIG. 2. MODEL OF HELL GATE; WHITE LINES ARE GRAPHS OF FLOATING CONFETTI, SHOWING CURRENTS

waves, which are about $3^1/_4$ hours out of phase and which differ by almost 3 ft in range. The height of the water at any point in the river is therefore due to the relative elevations of the water at the two ends.

Further, the water stage is affected by changes in cross section of the channel and by water coming through the Harlem River. Since the tidal movement is essentially due to the difference in head at the ends of the river, the time of slack and the strength of the currents are nearly simultaneous throughout the river; the former occurs approximately when the water-surface elevations at the two ends are the same, and the latter approximately when the difference in elevations is greatest.

Current velocities encountered in portions of the East River are the highest in the entire New York Harbor. The average maximum ebb velocities are 3.2 knots at Brooklyn Bridge, 4.8 knots in the west channel off Welfare Island, 4.6 knots in the vicinity of Hell Gate, and 0.5 knots at Throgs Neck. The average maximum flood velocities are generally slightly lower. The irregular character of the currents is caused to some extent by the sudden increase in depths north of Welfare Island and in the vicinity of Hell Gate.

Under existing conditions of tidal currents and channel curvature, large ships can use the route for only a limited period between high and slack water. Insufficient channel depths and adverse alinement of currents limit the size of ships and the time of passage.

The most serious obstacle is the reverse curve encountered at Hell Gate (Fig. 2). The first turn into Hell Gate, going north from the west channel off Welfare Island, involves a change in direction of about 52°, on a curve whose radius is 1,470 ft. The second curve, in the reverse direction, involves a change in direction of 38° with a radius of 1,530 ft. A tangent of only 1,800 ft connects the two curves.

OBJECTIVES OF IMPROVEMENT

In order to assure safe navigation for large vessels from the Battery to Long Island Sound, the following general conditions are required:

1. Minimum depth of channel should be 40 ft.
2. The radius of curvature of the center line of the channel should not be less than 3,000 ft, where a change of course of 30° or more is involved, and the straight-away between curves should be not less than 2,000 ft, to permit a vessel to "steady" between turns.
3. Undesirable currents should be corrected and desirable ones should be retained so far as practicable.

The model study was initiated to find a satisfactory method of meeting these requirements in the vicinity of Hell Gate and Belmont Island. The objective of the studies in the vicinity of Hell Gate was a satisfactory alinement (for large vessels) of the main currents without destroying the low-velocity eddies which are utilized by the towing traffic in negotiating this difficult section of the river. At Belmont Island it was a realinement of the main set to overcome the existing tendency of the river currents to throw ship traffic onto the Manhattan shore.

A model was made to reproduce that portion of the East River from the Battery to Clason Point, and the Harlem River to Spuyten Duyvil (Fig. 1). The bed was molded in concrete to conform to a survey made in 1935–1936 by the U.S. Engineers. Changes from one set of model conditions to another were simplified by molding Hallets Point, Hell Gate, Little Hell Gate, Belmont Island, and other minor sections in removable concrete blocks. All wharves were simulated with 4-mesh screen wire. Gages were placed at locations corresponding to those of all reliable gages in the prototype. The model was built to a horizontal scale (length) of 1 to 480 and a vertical scale (depth) of 1 to 80, with a resulting geometric distortion of 6. Thus it was about 150 ft in length and 60 ft in maximum width.

SOME FEATURES OF MODEL OPERATION

Since the model was to simulate forces with respect to gravity, further scale relationships for transference of data from model to prototype values were chosen as follows:

Area, a function of $(\text{length})^2$—1:230,400
Velocity, a function of $\sqrt{\text{depth}}$—1:8.94
Discharge, a function of (length) × $(\text{depth})^{5/2}$—1:344,000

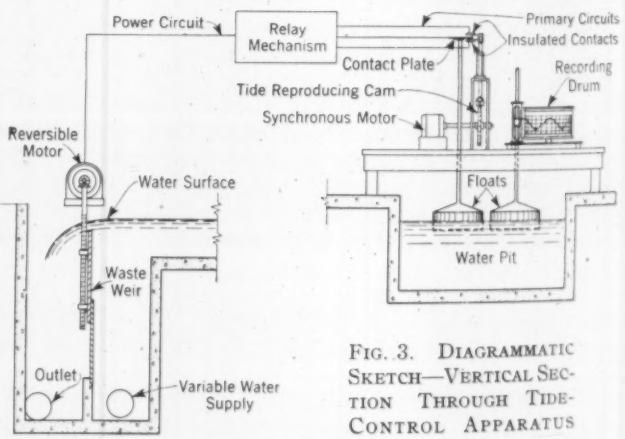


FIG. 3. DIAGRAMMATIC SKETCH—VERTICAL SECTION THROUGH TIDE-CONTROL APPARATUS

Time, a function of (length) × (√depth)—1:53.7

It will be noted that the time conversion factor was such that 1 minute of model time represented almost 1 hour in the prototype. This condition made it impracticable to measure and sketch the rapidly changing tidal currents, which data are essential in comparing the various plans. Therefore, photography was used, with floating confetti to give streaks representing the pattern and direction of the surface currents (Fig. 2). Photographs made at intervals of 53 sec with exposures of 1 sec gave the most satisfactory results. They were supplemented with motion pictures, and this combination made it possible to visualize resulting conditions more readily than would tabulations and charts alone.

FIG. 5. TEST OF FINAL IMPROVEMENT PROPOSED FOR HELL GATE—WITH CURRENT DIRECTIONS AT FLOOD TIDE

An electro-mechanical tidal apparatus (Fig. 3) made it possible to reproduce the tides and currents to the proper time scale. A cam with a polar plot of the tidal curve was rotated at the proper speed by a synchronous motor. Riding on the cam was a split contact, while another contact was riding on a float. Thus one contact reflected the water-surface elevation as it should be, and the other, the actual surface. When they were not in agreement, contact was made and a reversible electric motor operated a movable waste weir to lower the gate in the case of a water surface which was too high, and to lift the gate for the opposite condition. The process was one of hunting, and the water surface was always at approximately the correct elevation. Such discrepancies as existed were corrected by adjusting the model roughness.

TO VERIFY THE MODEL

Value of a model depends on its ability to predict with reasonable accuracy the action to be expected in the prototype under similar conditions. It is essential, therefore, before studying the proposed plans for improvement, to test the model's ability to produce dependable results, and also to determine their approximate accuracy.

This is known as the "verification of the model." The first step was to adjust the tidal mechanism to reproduce to scale the tide heights and current directions at three control stations. Next, adjusting the roughness of the channels to obtain the correct velocities and tides at intermediate gates involved covering most of the model with a roughness resembling that of a stucco finish. The final step was a thorough check of the tides, current velocities, and current alinement in the model. These observations were compared with field data taken from the prototype. Verification of the model included reproduction of the average spring tide at 15 gaging stations; reproduction to scale of prototype velocities; and scale reproductions of the proper times of occurrence of high and low water, slack tide, and strengths of the ebb and flood tides, in both the East and Harlem rivers and in Little Hell Gate.

A very satisfactory verification was obtained, because of the quantity of observed data available from field surveys. Actual tests of proposed improvement plans were then begun, with continuous records of the tide at the control gages and at Mill Rock, by means of automatic recording gages. These records provided a check on the accuracy of the model and quickly revealed any failures to function properly.

Altogether, 20 separate and distinct plans were investigated; of these 16 involved proposed changes at Hell Gate. The test of the plan originally proposed for that locality and the plan finally recommended will be briefly discussed.

The improvement originally proposed (Fig. 4) involved the deepening of the main channel of the East River to 40 ft at mean low water, the deepening of the channel east of Welfare Island to 25 ft at mean low water, the complete removal of Hallets Point, the widening of the channel between North and South Brother islands to 1,000 ft by the removal of a large portion of South Brother Island, and a fill over Sunken Meadow.

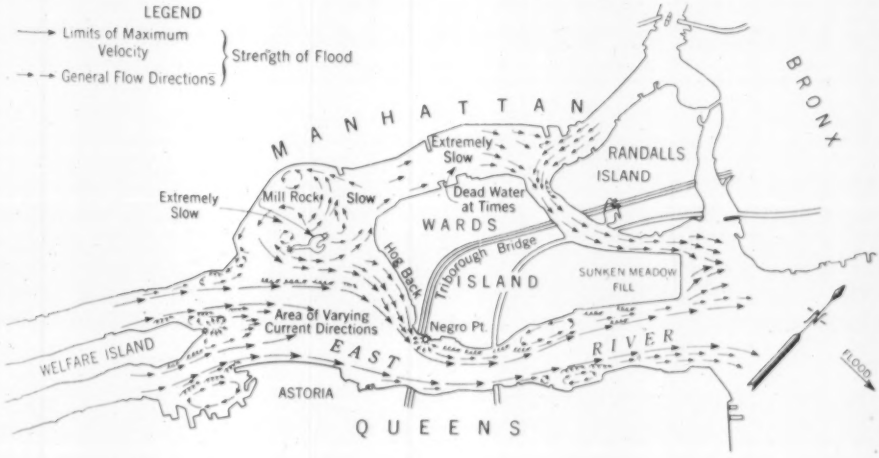


FIG. 4. TEST OF ORIGINAL IMPROVEMENT PROPOSED FOR HELL GATE SHOWING CURRENT DIRECTIONS AT FLOOD TIDE

Considerable improvement in current alinement resulted from eliminating some of the excessive reverse curvature through Hell Gate. Of particular note, however, was a large area of indeterminate and varying flow immediately north of Welfare Island on the flood tide. This phenomenon (Fig. 4) tended to maintain the northerly set of the currents from

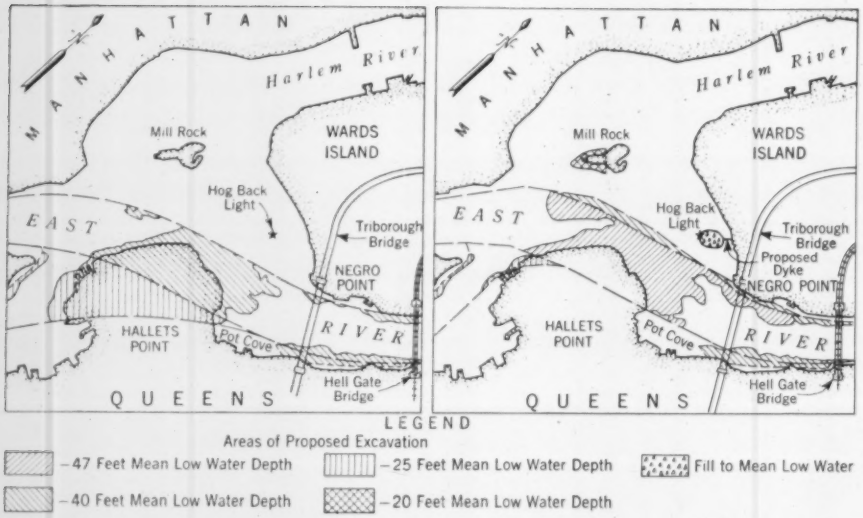


FIG. 6. COMPARISON OF SOLUTIONS AT HELL GATE
Left, Desired or Original Plan; Right, Recommended or Final Plan

the west channel, thus limiting the improvement of current alinement on the flood tide.

A complete change in the direction of flow in the vicinity of Mill Rock was caused by this plan. The area between Mill Rock and the east bank of Manhattan Island was occupied by a series of slow eddies, and the direction of flow in the channel between Mill Rock and Wards Island was reversed for both the ebb and the flood tides.

On the flood tide the alinements of the currents were definitely improved over original conditions, but did not comply fully with the desired alinements. The area of partially dead water immediately north of Welfare Island was filled with boils and eddies. The alinement of the flood currents in the vicinity of Negro Point was not materially improved.

On the ebb tide the current alinements were satisfactory, and it was noted that the tangent distance between the reverse curves greatly exceeded the required 2,000 ft. However, since the center of the main set passed within 100 to 200 ft of the edge of the 25-ft dredging limits, the further removal of much of the southwest edge of the 25-ft dredged ledge would be necessary for safe navigation of large vessels.

AS FINALLY RECOMMENDED

The plan which offered the most practicable solution (Fig. 5) included the following specific improvements:

1. Widening the bend in the channel south of Belmont Island to a depth of 40 ft.
2. Dredging a cross channel 20 ft deep and 1,000 ft wide between Belmont and Welfare islands.
3. Dredging the East Channel at Welfare Island 25 ft deep and 500 to 600 ft wide.
4. Removal of the northwest portion of Hallets Point to a depth of 47 ft, and dredging the channel adjacent to the point to a depth of 47 ft; also, removal of the southwest corner of Hallets Point to a depth of 25 ft, and the northeast corner to a depth of 40 ft.
5. Removal of the southern arm of Mill Rock to a depth of 20 ft.
6. Removal of the ledges near Mill Rock and along the east bank of the East River in the vicinity of the Triborough Bridge, to a depth of 40 ft.
7. Filling an area in the vicinity of Hogs Back Light to an elevation of mean low water and constructing a dike to an elevation of mean low water, from the north side of this area to Wards Island.
8. Cutting back Negro Point, on Wards Island, to a depth of 40 ft, to within about 20 ft of the face of the Triborough Bridge pier.
9. Dredging a channel 40 ft deep and 650 ft wide between North and South Brother islands.

The major difference, in the vicinity of Hell Gate, between the plan originally proposed and the plan finally recommended was in the portion of Hallets Point to be cut away (Fig. 6). The original plan provided for complete removal of Hallets Point, while the plan which offered the best solution as determined from the model study provided for removal of only a portion. This plan required less excavation and the acquisition of less property.

These improvements resulted in current alinements which satisfied the requirements. A ship could follow the desired navigation line and remain well within the main set, and there was the further advantage of visibility over the entire Hell Gate reach.

On the flood tide (Fig. 5) the current coming out of the channel east of Welfare Island followed the Hallets Point shore quite closely; the currents from the western channel were deflected somewhat by a strong boil over the south end of the Mill Rock ledge; and the main set passed approximately through its natural position. A large slow eddy was noted encircling Mill Rock, the current flowing in a westerly direction between Mill Rock and Wards Island. The eddy area off Negro Point was not very wide at the full strength of the tide, and became smaller as the current velocity decreased. At full tide strength there was considerable flow over the Hogs Back fill and dike.

On the ebb tide the main set passed approximately 500 ft east of its natural position; there was a smooth division of flow on the northern point of Welfare Island (the main set entered directly into the western channel); and there was comparatively little movement in the area west of Mill Rock and in the lower Harlem River. There was a slight easterly flow between Mill Rock and Wards Island. The water over the Hog Back shoal was almost slack, the dike and fill effectively cutting off any cross flow. Some boils off Pot Cove and eddies along the Hallets Point shore were observed.

SOLUTION WAS SUCCESSFUL

The conclusions drawn from the model studies were that the complete removal of Hallets Point, as originally proposed, resulted in no advantages in current alinement which were not obtainable under plans requiring less excavation. In addition, the complete removal of Hallets Point resulted in the formation on the flood tide of a large area of eddies, boils, and slack water immediately north of Welfare Island. The partial removal of Hallets Point embodied in the plan finally recommended gave the most favorable current conditions. Overdredging of the channel through Hell Gate to 47 ft resulted in improved current alinement. The tests determined a plan of improvement which gave the best navigating conditions, and which cost less than any other plan providing the same results. The project which embodies this plan, estimated to cost $34,509,000, was recommended by the Chief of Engineers, December 11, 1939, and is included in the pending Rivers and Harbors Act.

Modern Heavy Excavating Equipment

SPECTACULAR performance and economy have characterized the development of earth-handling equipment. This is most fortunate because, with all-out war demanding more than ever from engineers, it has devolved upon contractors and machinery manufacturers to make provision to meet the new demands. Examples of the phenomenal progress made are given here in two papers, each by an expert in his field, one dealing with types of tractor-scrapers and the other with shovel and dragline units. This picture of what gigantic strides American engineering has taken—the accomplishments achieved and the efficiencies attained—in excavation, one of the oldest fields of construction, will have special interest. These two papers, Mr. Park's first and Mr. Ruhloff's as supplemental to it, were originally delivered before the Construction Division at the Society's Spring Meeting in Roanoke in April.

Tractor-Scraper Machines in War Work

By KENNETH F. PARK, ASSOC. M. AM. SOC. C.E.
CHIEF FIELD ENGINEER, R. G. LETOURNEAU, INC., PEORIA, ILL.

WITH their keyed-up organization and modern heavy construction equipment, contractors are pledged to an all-out civil defense effort. Their efficiency in engineering and construction practice is of inestimable value to our war program. In these times when expenditures are measured in billions of dollars, excavation quantities in hundreds of millions of cubic yards, and efficiency in terms of completion dates, no other group in the world could step into the breach and so quickly hit the necessary production pace. Present-day heavy construction equipment has made this possible.

In discussing such equipment, the first question asked will probably be, What determines whether or not a certain machine is "heavy"? To paraphrase an old saying—"Heavy is as heavy does." Take the case of an old-model tractor with a shipping weight of 21,000 lb, an engine of 55 hp, a maximum drawbar pull of 9,700 lb, and a top speed of 3 mph. It was, and it still is, considered as heavy equipment. Its nearest counterpart today weighs 24,000 lb; it is of 80 hp, and has a maximum drawbar pull of nearly 23,000 lb and a top speed of 6 mph.

But when we look at the performance of the two, the difference is remarkable. On a typical haul of 600 ft, pulling the companion scraper of its day, the old machine would excavate, haul, and place approximately 34 cu yd an hour; the new one approximately 92, or up to a possible 100 cu yd per hour, depending on the condition of haul roads.

It is the development of comparable improvements in all construction equipment, plus the greatly increased size of machines, that today makes possible performance of the enormous amount of work we as a nation are turning out. Without this great improvement, which has developed in the last decade, we would not be able to handle 30% of the production now reaching its top stride. Then "too little, too late" might well have been written against our present construction activities.

TO MEASURE TOTAL CAPACITY

To understand the prodigious amount of work now in progress, it is necessary to make an estimate of the number of machines in use in the war effort. It can be said that all the machines built for construction purposes in the past five years, or back through 1937, are at present in active war work. Antedating these models are many, of course, that are still able to offer performances comparable to those for which they were originally built. In my country-wide travels I find equipment dealers sold out, even to many old rehabilitated machines which they considered as scrap. I must qualify these statements by limiting them to excavation—the work with which I am most familiar.

It is probable that increases in shovel manufacture give us today at least 10,000 shovel units, 5 years or less in age, digging at war-time dirt. Assuming one hundred yards of excavation an hour, this would indicate the possibility of digging 1,000,000 cu yd an hour with shovel equipment alone. A typical truck requirement for such excavation might be approximately 50,000 units. These are conservative figures; the actual quantities may well be considerably greater.

During this same five-year period, approximately 100,000 tractors have been built and 25,000 have been placed on construction work, with somewhere near 15,000 on scraper units. The hourly potential of this group is estimated conservatively at 1,500,000 cu yd an hour.

Excavating equipment, then, outside of short-haul work such as is typical for a bulldozer, may be said to have a working capacity of at least 2,500,000 cu yd per hour. To indicate the number of jobs that could be worked simultaneously at this time, let us take all the machines available for excavation and set up 2,000 cu yd an hour as a progress rate. We could then handle 1,250 such jobs. Probably many more than this are actually in process of construction.

To this set-up may be added the rest of the 1942 output. This would include, besides shovels, another 27,000 tractors, of which it is probable that some 6,000 will go into excavating work on scrapers.

All this equipment now in use is not working in the United States. This is a war total, including the machines in off-shore work and in the territories in which we now fight, or to which we furnish equipment. They

TRACTOR-SCRAPERS AND OTHER EQUIPMENT HANDLE 300,000 CU YD OF DENSE CLAY ON CAREY DAM IN IDAHO

have been working from the Arctic to the Antipodes, and from Britain to Burma. They have been valiant in building new roads and throwing up tank traps; in excavating for munition dumps and smoothing out shell holes in bombed runways. They are working in the shadow of the Pyramids and in the depth of tropical jungles.

Of the scraper equipment previously mentioned, over 3,000 units are operating in foreign fields, from our one company alone. Many also are temporarily hors de combat at the bottom of the Atlantic until such time as the ingenuity of some contractor contrives a subaqueous use.

Considering that this equipment is operated by man power—and most of it all the way around the clock—the skilled and semi-skilled labor involved is a problem in itself. It is estimated that no less than 300,000 men would be required per day on working units alone—on shovels, trucks, and tractors—to keep the dirt flying.

After proper headway had been gained, a typical big Army camp job, including great quantities of work outside of excavation, maintained an average of nearly 30,000 working people per day. The number of skilled and semi-skilled operators on excavating, grading, and maintenance equipment alone represented 8% of the total. If the same proportion were applicable to all the jobs on which the available equipment is being used, it would call for 3,750,000 people to carry out the work in which tractor-scraper and shovel equipment is participating.

TO QUALIFY AS A BIG JOB

There may be a reasonable difference of opinion as to what constitutes a "big" project. I have arbitrarily considered that handling 2,000 cu yd or more of excavated dirt an hour would qualify for such a designation. On the basis of this progress requirement there are many big projects today. The dirt must be hauled to some final resting place and made stable for building sites, airport runways, camps, or other war projects.

When the big excavation job of a few short years ago had, say, two million yards to be handled in a year and a half, at a required rate of 300 to 400 cu yd per hour, we felt we had hold of a pretty big task. We now have to increase the output many fold to create what the contractor chooses to classify as a "high-ball" job.

Two years ago a 31,000,000-yd earth-fill dam was advertised for bidding. The amount of yardage in the job took all our breaths away. Excavation was set up at approximately 1,400-cu yd an hour. Approximately $1,500,000 worth of equipment went onto the job—we roughly estimated that there was about 20 cu yd of excavation for each dollar invested in machinery.

A fair-sized earth-fill dam of a few years ago, with 3,000,000 cu yd of excavation, was given three years to complete. Compare that with a defense processing plant recently started which had nearly 4,000,000 cu yd of excavation, and which had to be completed in 90 days.

Some details as to what modern equipment is producing will be of special interest. On the Army camp work previously mentioned, 19 complete grading outfits belonging to outside contractors, complete with operators, were hired. These included shovels, trucks, and tractor haulage units, bulldozers, graders, and rollers. On the 31 miles of railroad work involving 1,235,000 cu yd of excavation, there were nearly 300 units working. In the road work with tractors, graders, trucks, and scrapers, there were 460 units working. In traffic and maintenance there were 18 units. This makes a total of 778 units on excavation alone on a single project.

Great amounts of other equipment were also in operation on the job, and enormous quantities of materials were being handled to form a permanent camp. For instance, nearly one million board feet of lumber were nailed up each day. No total excavation quantities are available on most of these jobs, but they run into staggering amounts.

FROM THE CONTRACTOR'S NOTEBOOK

Another war job, an ordnance plant, typical of so many of our large present-day projects, was to be completed in one year. Some of the quantities involved will indicate the tremendous size of the job: grading, 1,600,000 cu yd; concrete, 130,000 cu yd; and steel, 20,000 tons. It was necessary to build 74 miles of standard-gage railroad on the site, 74 miles of permanent roads, and 30 miles of temporary roads. The floor space in the buildings amounts to over 2,000,000 sq ft.

A list of the equipment for the work included 20 shovels, cranes, and draglines ranging from 1 to 20-cu yd capacity; there were 38 tractor and bulldozer units; and sixteen 12 to 16-yd scraper-tractor units. The rest of the equipment consisted of locomotives, cranes, rooters, ditchers, compressors, graders, rollers, various types of finishers, concrete mixers, and so forth. All told, there were 160 pieces of equipment on the project.

Let me quote one more typical excavating job—the preparation of a large area of ground for a war product plant. There were enough extra units on the job to insure the 21-hour operation of 25 scraper units. Working in conjunction with them were several tractors as rooting units, and several which assisted in loading as "pusher" units. The scrapers ranged in size from 14-yd heaped to 30-yd heaped. A group of four had rubber-tired tractors for long haul. The work was laid out to handle 100 cu yd per machine, on all the hauls involved, of whatever length. Individual 14-yd scrapers were placed on short-haul work, handling dirt up to a distance of 500 or 600 ft. Larger tractor-scrapers, loaded by pusher, were placed on the intermediate hauls up to 1,500 or 1,600 ft. Rubber-tired units, with their inherent speed, were used on long hauls, up to a mile or more.

By maintaining 2,500 cu yd per hour, the flow of material to the fill, where it had to be processed by spreading and tamping, was made constant. The working crew was maintained at constant levels, both as operators for the units themselves and as repair and grease crews. A gross amount of 50,000 cu yd a day or more was the average maintained throughout a period in which many million yards were handled.

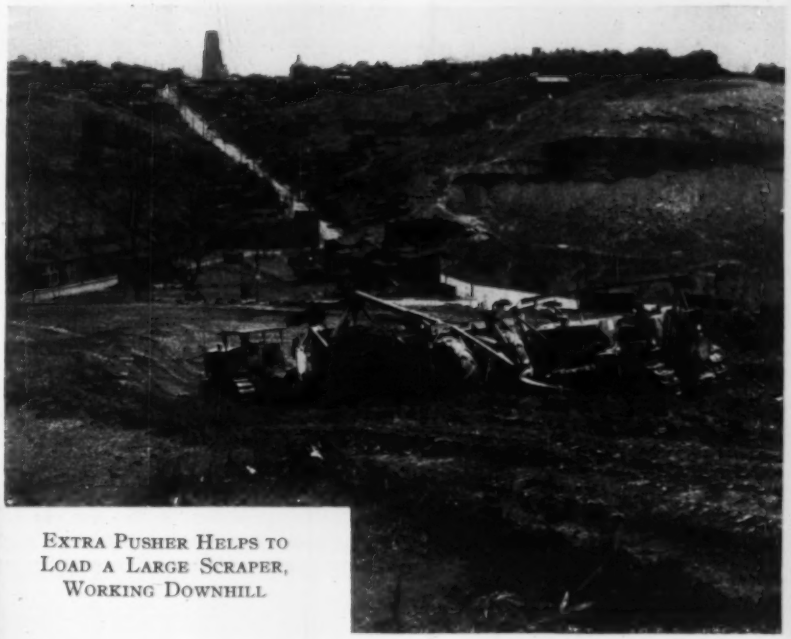
Since excavating machinery is shown to have undergone such outstanding improvements, some explanation should be made as to how this was possible. I will confine myself to a consideration of the type with which I am most familiar—tractor-scraper equipment. As one contributing factor—tractor horsepower, weight, speeds, and design have all improved, so as to offer several times the performance originally possible. Bulldozers, rooters, and particularly tractor-scrapers, however, have been the biggest contributing factors in the development of the tractor. If the capabilities of the tractor-scraper had not always challenged more than every ounce of power a tractor was capable of developing, the possibilities of such development would have been remote. Actually the progress in performance and economy of tractor-drawn units during the past ten years has been spectacular.

When first used as a tractor-hauled unit, the best scraper was a hard-loading, clumsy, steel-wheeled, small-capacity machine that consumed over 400 lb of tractor drawbar per ton of trailed load. The largest present-

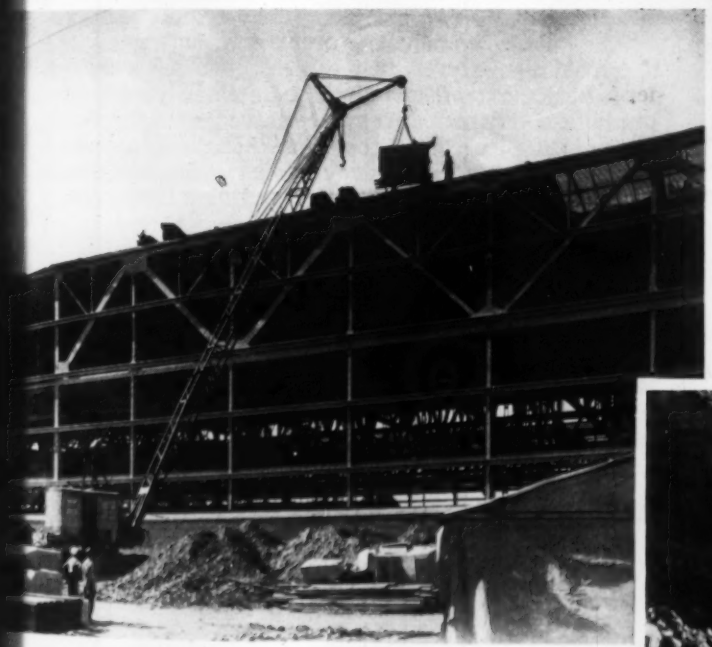
On a National Defense Project—Shipyard Construction on the West Coast
Pusher Helps to Load 23-Yd Scraper

This 4-Cu Yd Shovel Is Operated as a Dragline, to Load 20-Cu Yd Trucks

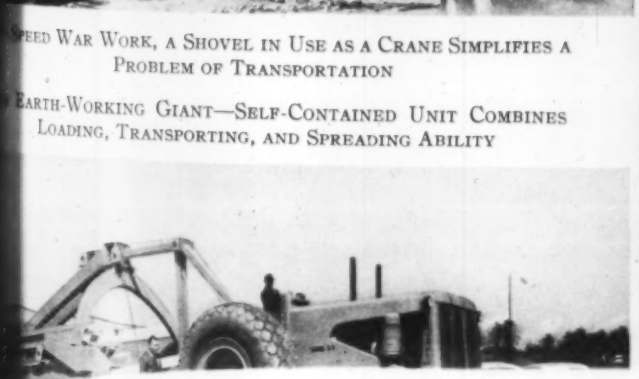
oter Breaks Shale Rock, to Be Picked Up by Scrapers
This Is for an Airport in Pennsylvania



Extra Pusher Helps to Load a Large Scraper, Working Downhill



Riprap for Navy Use Is Loaded on Flat Cars by a 5-Cu Yd Electric Shovel



peed War Work, a Shovel in Use as a Crane Simplifies a Problem of Transportation

Earth-Working Giant—Self-Contained Unit Combines Loading, Transporting, and Spreading Ability

day machine, with properly applied pneumatic tires, has over seven times the capacity and under comparable conditions will haul with but 11% more tractor drawbar pull. On yesterday's machine, a 13-ton load, using 5,850 lb of drawbar pull, in most cases would require the same gear and speed necessary for one of today's scrapers with a gross load of 93 tons, requiring but 6,510 lb of rim pull. This difference accounts for the greatest part

EARTH MOVING WITH HEAVY EQUIPMENT TO CONSTRUCT AN AIRPORT RUNWAY IN THE MIDDLE WEST
A Million and a Half Yards of Earth Was Handled on This Job

of the increased production of present-day heavy tractor grading equipment.

Another improvement adding to the effectiveness of scraper operation is the recently developed automotive-type rubber-tired hauling unit. What it has done is to take over the highly developed scraper with all its economies, adding to it the missing factor of speed.

In its most recent form—for the sake of clearer understanding, let us call it a truck-scraper combination—we have all the economies of the tractor-scraper, plus the speed of the truck. The results are greater yardage for less cost—more work accomplished in a shorter period of time. Short-haul economies are thus possible on long-haul work. This type of machine has brought the borrow pit thousands of feet closer to the fill.

TODAY'S MECHANICAL MONSTER

To illustrate the growth in size, I would mention the newest and largest machine developed for fast and economical earth movement. It loads with pusher help, or by snatch pulling, or by a combination of the two; but it contributes enormously to the amount of dirt moved through its own power. The machine has dual 200-hp motors, working through individual fluid couplings to a single reduction shaft. Standard transmissions would not handle all the power flowing from the engines, so a series of clutches handle four forward speeds, through gears running continually in mesh.

Taking the tractor unit alone—the weight on two 30.00–40, or 36.00–40 tires, is 44,000 lb. It trails a scraper unit which weighs over 50,000 lb empty. The tires on the rear of the scraper are dual 24.00–32, 34-ply. The machine has a struck volume of 42-yd, and a heaped capacity of 59 yd. Properly applied, in good going, it has picked up 136,000 lb of dirt. With such loads, the gross weight of the entire machine is approximately 230,000 lb. On fair roadways the unit will travel at 15 mph.

The calculated drawbar pull, or more correctly the rim pull (power applied to the tire rim) is nearly 55,000 lb—over twice as much as the largest tractor now made. Obviously this power is only usable before the wheels slip, in proportion to the ability to hold the machine down on the ground. In average dirt, the coefficient of friction is 0.55. On this basis, the effective pull becomes 55% of 55,000 lb. The complete development of rim pull for towing comes nearer its full development as we get more and more weight on the tires in various loading procedures.

On this machine the biggest tire used has a carrying capacity of over 55,000 lb, using a 35-lb pressure. It weighs about 3,800 lb and stands 114 in. high. It has 38 plies and retails for approximately $5,100 per tire.

It might be interesting to state the size of this big carrier in commonly understood terms. An ordinary wheelbarrow would carry about 150 lb of dirt. A 136,000 lb load would make over 900 wheelbarrow loads. In the same two minutes that it would take a laborer to load the wheelbarrow, we can heap the scraper.

TRANSLATED INTO WAR ACCOMPLISHMENT

"Comparisons," as Shakespeare once said, "are odious." But I have already made many, so one more will not matter. A comparison of machine costs on a typical mile haul will indicate the efficiency of our present-day heavy grading equipment over that of yesterday. With the machine group now developing the cheapest costs, we can handle much greater quantities of excavation at one-third the cost and nearly three times the speed.

Study for a moment the problem of moving a year's output of dirt to meet the requirements of the war effort. Yesterday's equipment would take three years. That would be a very serious prospect in the face of the present crisis. Another thing, the three billion dollars which represents the approximate cost of moving that dirt at present prices, would be tripled and nine billion dollars would be required for the same work. Serious indeed would be such an addition to our present financial load.

During this critical period of speed-up, when it is necessary to accomplish more than we ever before thought possible, the contribution of heavy grading equipment to the rate of work and to the general advancement of our war program is enormous. So I give all credit to the ingenuity and aggressiveness of the manufacturers who have brought this equipment into being—and high praise to the contracting fraternity who are doing such a splendid job of using it.

Shovel and Dragline Performance

By F. C. RUHLOFF
SALES ENGINEER, BUCYRUS-ERIE COMPANY, SOUTH MILWAUKEE, WIS.

AMONG the means of meeting the heavy schedules of war construction, shovels and draglines certainly take a prominent part. Their application to present-day engineering construction is a notable one. Great strides have also been taken in developing increased capacity and performance in this type of excavating equipment to handle the growing demands of large-size projects.

Just what proportion of such excavation is handled by shovels and by draglines is a matter of estimate only. Further, it is changing due to increased manufacture. For example, the current year's production of such ma-

chines will greatly exceed last year's output of four thousand or more units.

An analysis of our shipments for the first quarter of 1942 shows a 25% increase in balanced average dipper capacity for all $^3/_8$ to 3-cu yd shovels—this in spite of the large number of $^3/_8$-cu yd machines shipped. This further adds to the possible output. Thus, the potential hourly excavating capacity available for construction from machines placed in service during the last five years is doubtless over $1^1/_4$ million cubic yards per hour.

SHOVEL, TRACTORS, AND TRACK WAGONS ON A STRETCH OF HEAVY ROAD CONSTRUCTION THROUGH ROCK

SPECIAL ABILITIES

The actual hourly excavating capacity will be less than the potential because shovels or draglines are now purchased with additional equipment to make them serve also as general utility tools—as cranes or clamshells. The extent to which this has gone is indicated by the mounting of a $2^1/_2$-cu yd shovel on an automotive truck to enchance its maneuvering ability in crane service.

Shovels and draglines have special advantages in work where the material is rock or the haulage distance controls. Tractor-drawn equipment, on the other hand, is ideally suited to present-day construction work involving an immediate start at a number of places simultaneously. Thus, in general, each type of excavating unit has a distinct field, but the border between them is not distinctly defined.

Now in use on construction projects, exclusive of mining and normal quarry operations, are 26 electric shovels of one manufacture normally rated as of 5-cu yd capacity. These are of the type with which I am most familiar. In average excavating service they would have a potential capacity of 15,000 cu yd per hour. This indicates a trend toward the use of heavy-duty electric excavators on construction work.

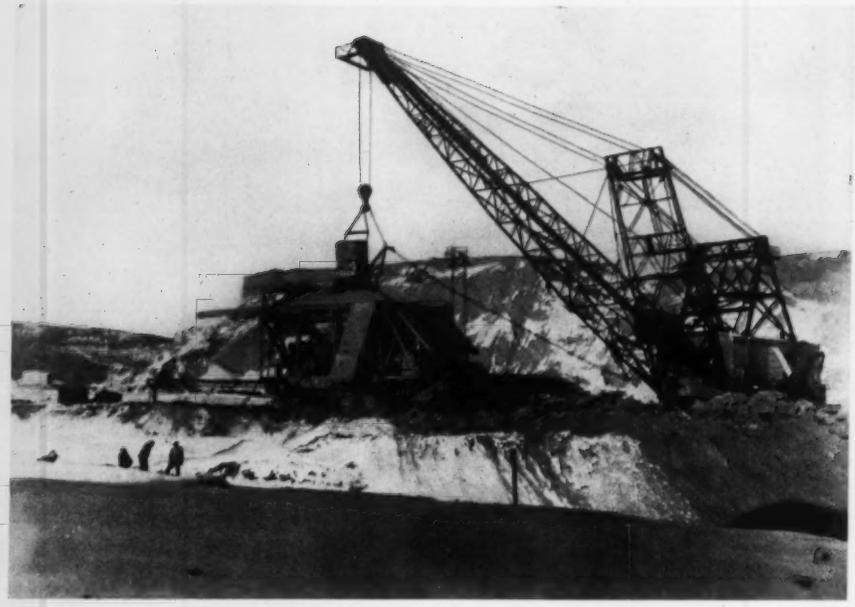
This machine, which is designed for quarry and mining work, is convertible to a dragline; and as a crane it would handle a 4-cu yd concrete bucket (20,000 lb) at 100-ft radius. Its variable voltage control permits both raising and lowering of the load on the motors. The utility feature of alternative shovel, dragline, crane, and clamshell use has now been extended to include 5-cu yd electric machines.

There are now going into service two 4-cu yd electric shovels which have the capacity to feed 900 cu yd per hour to a belt conveyor having a length of 4,000 ft in the pit and then extending 8,300 ft from the pit to the dam. An exceedingly interesting feature of this digging and transportation of material is that in 7 flights the material is lowered 735 ft, which down movement generates a net of 618 hp. This gain is accompanied by an extremely low shovel-loading cost.

REMOVING OVERBURDEN 70 FT DEEP IS THE EXCAVATING TASK SET FOR THIS HUGE 30-CU YD SHOVEL

Merely mentioning capacity in terms of cubic yards per hour is not a true measure of performance. For example, a 30-cu yd shovel has had a monthly average production of 1,700 cu yd per digging hour in material requiring blasting. Although as a mining tool this machine is doing an outstanding production job, it would be entirely unsuited for the type of work involved in building airports or preparing land for building projects. But for canal work or tailraces cut in rock for large power projects, it is eminently suitable.

A 10-cu yd dragline has delivered 530 cu yd per operating hour to a hopper feeding a belt conveyor over a



A 10-CU YD DRAGLINE LOADS A CATERPILLAR-MOUNTED HOPPER, WHICH IN TURN FEEDS A BELT CONVEYOR

mile long. This is the type of service for which such a unit is better fitted than any other. It illustrates the fact so well recognized by construction engineers, that each job of magnitude poses its own problem in developing machines of the most suitable types.

PARTICULAR APPLICATIONS OF IMPORTANCE

The long-boom dragline is finding greater use on construction projects. Machines of this type are in service on varied work, as the following list indicates:

1. Panama Canal—Third Lock Project
2. Columbia River—Bonneville Power Plant Development
3. Anderson Ranch Power Dam
4. Shasta Dam—aggregate plant
5. Breakwater and harbor projects
6. Draglines arranged for clamshell work mounted on floating hulls—Pearl Harbor and elsewhere in Hawaii

Draglines combine the functions of digging, lifting, and transporting material. Within the limits of their boom lengths, they make for low-cost movement. A 12-cu yd dragline, in overcasting blasted shale, operated 984 shifts in a year and moved 3,716,000 cu yd at a direct operating cost of $0.0191 for labor, supplies, repairs, and power.

Draglines whose buckets are too large for the average truck are operating with belt transportation—for example, in digging the aggregate for Shasta Dam and delivering it to the 9-mile belt conveyor. On an Alaskan mining project, a 12-yd dragline with a 200-ft boom delivered material to a mobile caterpillar-mounted hopper, which transferred it to a conveyor serving a spoil pile about a mile and a half from the pit. This indicates the possibility of using large dragline buckets for digging various types of material and successfully transporting it on belting. This trend will become more prominent since belting engineers have assured us that they are in a position to take rock as large as a 4-ft cube on a 74-in. belt; and that they are willing to transport it providing the elevation is suitable and there is no transfer of material between receiving and discharge points.

To indicate the advancement in the art of digging by means of draglines, it should be noted that machines are available which carry either a 250-ft boom with a 14-cu yd bucket or a 180-ft boom with a 25-cu yd bucket. At a normal dragrope pull of 186,000 lb, a 25-cu yd bucket can dig and haul at a speed of 200 ft per min. This bucket when loaded weighs 125,000 lb and is lifted at a rate of 260 ft a minute; this indicates the high speed of transportation that can be attained within the operating range of the machine. This dragline has a capacity of approximately 1,000 cu yd per hour.

In one of the new developments, the dragline drum and the hoistline drum are each independently motorized under variable voltage control, eliminating the usual operating clutches and brakes. This improves control, increases output, and decreases operating costs and delays. It requires two motor-generator sets furnishing direct-current power to two 425-hp hoist motors, to two 425-hp drag motors, as well as to three 125-hp swing motors.

Briefly, the contractor has available a choice ranging from $^3/_8$ to 33 cu yd in shovels, and from $^3/_8$ yd to 25 cu yd in draglines. It is significant to note that the largest shovel requires only the three-man crew generally used on a small unit.

The capacity and transportation range for the largest units are as given in Table I.

Selection of the proper unit depends upon the class of material, the hourly demands, the operating range, the coordinating transportation system, and total yardages to be moved. The number of units may be further dependent upon the number of points of application required.

TABLE 1. DATA ON SIZE AND PERFORMANCE OF LARGER SHOVELS AND DRAGLINES

TYPE	SIZE	MAXIMUM MOVEMENT OF MATERIAL TO DUMP, FT		MAXIMUM* HOURLY OUTPUT, CU YD	WEIGHT IN WORKING ORDER, LB
		Horizontal	Lift		
Shovel	33 cu yd	200	68	2,000	2,800,000 (1,400 tons)
Dragline	25 cu yd, 180-ft boom	370	170	1,000	.....
Dragline	14 cu yd, 250-ft boom	500	250	600	.....
Shovel	$6^1/_2$ cu yd	86	31	800	487,000 (243 tons)

* Operating conditions and ranges will influence the output shown. These are primarily maxima for comparative purposes.

TREND TOWARD GREATER OUTPUT WITH LESS WEIGHT

Throughout the range of machines the trend is toward securing greater output with less weight. The now available 2-cu yd diesel shovel weighs 122,100 lb and can produce 250 cu yd an hour. Ten years ago a 2-cu yd diesel shovel weighed 141,000 lb and was rated at 200 cu yd an hour. Similar changes have occurred throughout the whole line of excavating units.

The several types of units have received their greatest variety of application on construction projects, a fact which made for rapid development. The engineer's demands and the engineer's help have been important factors in the significant progress of "earthmoving."

Sewage and Garbage Disposal Plant at Gary, Ind.

By W. P. COTTINGHAM, M. AM. SOC. C.E.
CITY ENGINEER, GARY, IND.

ANY new sewage disposal plant is of interest to the designing as well as the plant engineer. The Gary installation is of particular interest because of the data now available on the first year's operation. It serves 100,000 people with a separate digestion, activated sludge system. The experience records of the first few months show favorable behavior, similar to that of other plants in recent years. Gas production, to be augmented later when garbage grinding is instituted, has proved most economical. Especially notable is the experience with strong acid-pickling liquors, which have had a decidedly beneficial effect on the digestion. This paper is condensed from Mr. Cottingham's presentation before a session of the Sanitary Engineering Division at the Society's Chicago Meeting last fall.

AFTER more than a year's operation of Gary's new sewage treatment plant, it is possible to make some observations on its performance. Since the plant has gone through some of the seasons only once, it is not possible at this time to draw final conclusions as to what normal operation procedures will accomplish.

An activated-sludge, diffused-air type of installation was adopted, with separate sludge digestion. The plant was designed for a population of 170,000 in 1950 (of which about 100,000 are served now), and an average sewage flow of 40 mgd with a five-day B.O.D. of 111 ppm and suspended solids of 120 ppm. Since details have already been given elsewhere (*Sewage Works Engineering*, September 1940) only a brief description of the physical features is needed here. A general view, showing the relation of the various parts, appears in one of the photographs.

HANDLING THE RAW SEWAGE

As the sewage enters the plant it passes through 25-in. shredders, and practically all floating material is macerated. The greater part of the material designated as screenings is grit, which is deposited in the bottom of the pits. After passing through the shredders, the sewage flows to the suction conduit, where it is pumped to the grit chambers by one of the five sewage pumps.

Since the main interceptor to the plant is 72 to 84 in. in diameter and slightly over three miles in length, it is possible to use this sewer as a reservoir and maintain a fairly uniform rate of pumpage throughout the 24 hours.

The rate (Table I) is controlled by throttling the cone valves on the discharge lines of the sewage pumps and is regulated so that the interceptor is pumped practically dry in the early part of the morning and before the morning peak flow has reached the plant. This peak comes down the interceptor almost in a wave, carrying with it any deposits that may have settled out in the previous 24 hours. To date, inspections show that no septicity has developed in the interceptor, and the sewage reaches the plant with no indications of staleness. Sewage from the most distant point arrives at the plant in about eight hours. The average time required for all sewage to reach the plant is approximately four hours.

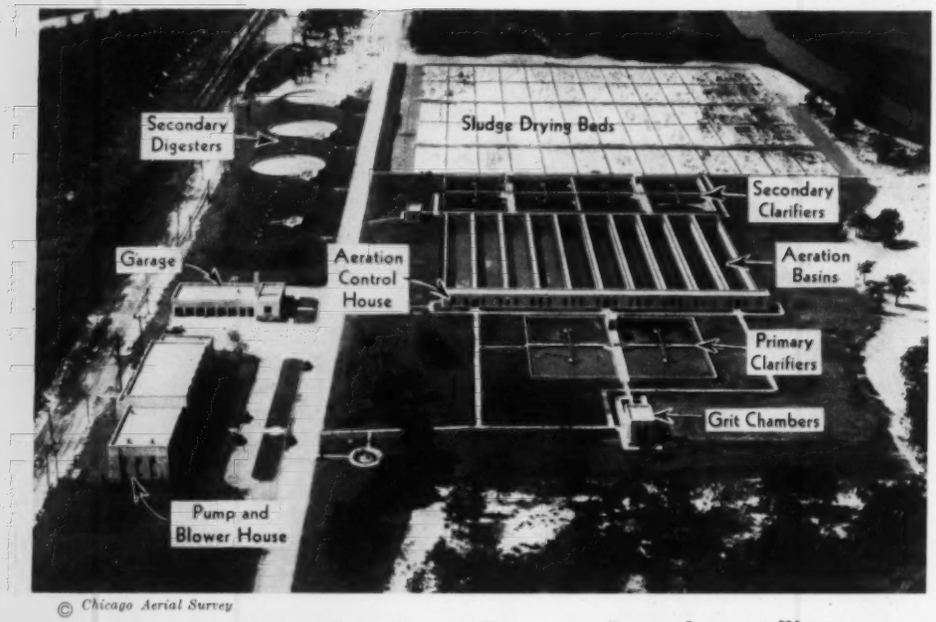
With a uniform rate of flow, "jolting" does not occur in any of the tanks. The organic load on the aerators in particular is more uniform than where the rate of flow in the sewers has to be followed closely by rate of pumpage. If gas production is below normal, the sewage pumps are operated at full capacity to conserve gas, and shut down during periods of minimum flow. As far as can be determined, this has no effect on the efficiency of the treatment process.

Grit removal equipment consists of two straight-line collectors, with screw collectors, of 20 mgd capacity each. Putrescible material in the grit averages 4.3%, with a

TABLE I. SUMMARY OF OPERATING AND ANALYTICAL DATA, JANUARY-DECEMBER 1941

ITEM	MAX.*	MIN.*	AV.†
Main quantities:			
Av. daily pumpage, mgd	24.89	14.04	19.38
Pumped with sludge gas, %	100	65.4	83.94
Air:			
For month, million cu ft	295.49	248.6	279.28
Per gal sewage, cu ft	0.70	0.44	0.52
Blown with sludge gas, %	100	87.1	96.4
B.O.D. removed per 1,000 cu ft, in lb	1.80	0.94	1.45
Gas production:			
Av. daily, thousands of cu ft	165.7	119.1	146.2
Av. daily, cu ft per cap.	1.65	1.19	1.46
Per lb solids added, cu ft	8.6	2.4	6.55
Per lb vol. solids added, cu ft	11.9	4.3	6.1
Screenings removed:			
Cu ft per million gal	0.26	0.03	0.10
Grit removed:			
Cu ft per million gal	4.05	0.68	3.51
Solids:			
Removed daily, dry basis, lb	43,963	15,747	32,412
Removed per million gal, lb	2,264	933	1,669
Per capita per day in raw sewage, lb	0.45	0.194	0.3368
B.O.D. values:			
Removed daily, lb	30,000	13,787	22,976
Removed per million gal, lb	1,709	690	1,201
Per cap. per day in raw sewage, lb	0.32	0.158	0.2443
pH values:			
Raw sewage	7.3	7.0	7.2
Clarified sewage	7.3	7.1	7.2
Final effluent	7.4	7.25	7.3
Raw sludge	6.9	5.9	6.6
Return sludge	7.3	7.1	7.2
Five-day B.O.D.:			
Raw sewage, ppm	214	112	154.8
Clarified sewage, ppm	131.4	49.2	95.7
Reduction, clar. to raw, %	60.2	17.5	38.1
Final effluent, ppm	15.3	4.9	8.80
Reduction, final to raw, %	97.2	86.4	94.3
Suspended solids:			
Raw sewage, ppm	245.9	138.3	208.4
Clarified sewage, ppm	145.3	72.7	112.7
Reduction, clar. to raw, %	66.1	25.2	45.9
Final effl., ppm	26.2	2.4	8.2
Reduction, final to raw, %	98.2	81.1	96.1
Misc. indexes:			
Sus. sol. mixed liquor, ppm	2,019	1,160	1,557
Sludge index (stan. methods)	134	69.4	88
Sus. sol. return sludge, ppm	7,787	4,010	5,588
Amount return sludge, %	35.0	25.2	29.7
Periods:			
Primary settling, hours	2.76	1.37	2.06
Aeration, hours	5.18	3.78	4.29
Second. settling, hours	4.10	2.58	2.97
Rate, gal per sq ft	1,903	533	747
Costs of treatment:			
Total per million gal	11.53	6.89	9.42
Per cap. (100,000 pop.)	0.0612	0.0495	0.05409
Per 1,000 lb B.O.D. removed	13.56	5.56	8.69

* Monthly averages.
† Annual averages.



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GENERAL VIEW OF GARY SEWAGE TREATMENT PLANT, LOOKING WEST

maximum of 10.2% and a minimum of 0.77%. Grit analyses are run weekly. The amount removed (Table I) is lower than would be expected from the sandy area characteristic of the lower end of Lake Michigan. It is discharged into industrial cars which are moved with a small gasoline locomotive, and used as fill about the plant site.

BEHAVIOR OF PRIMARY CLARIFIERS

Clarification is in four square, central-feed radial-flow type units. The detention period is 60 minutes at a 40-mgd rate. During the winter all four clarifiers are used to avoid freezing in units that otherwise would be out of service. This results in a settling period somewhat in excess of two hours.

A sludge blanket 18 in. thick at the outer edge of the clarifiers has been carried throughout the winter. The total depth of sludge, to the bottom of the sludge hopper, is approximately 8 ft, and the total amount in storage in the primary tanks corresponds with approximately 1,000,000 cu ft of gas. No septic action has been noticed in any of the clarifiers during the winter, but it has been necessary to reduce the sludge to 6 in. at times during the summer months. At various times all sludge has been pumped out of the primary clarifiers, when excess gas indicated that this was advisable.

When sludge pumping started early in the fall, the percentage of solids varied from 8 to 9%. Later, with a rise of temperature in the summer months, this gradually declined to between 4 and 5%. It is possible that the high early content was due to old sludge deposits in the sewers being washed down to the plant when the interceptors were put in service. Numerous bulkheads were built in the sewers by the contractors and some sludge remained in the sewers for over a year. Some digestion undoubtedly occurred in the sewer during this period. This sludge would naturally be heavier than fresh sludge and would tend to concentrate more in the primary tanks with the depth of sludge blanket maintained.

Raw sludge pumping is scheduled so as to disturb the sludge blanket as little as possible. Pumping out of the primary tanks is rotated at one-hour intervals so that any tendency for the sewage to break through the blanket is kept at a minimum.

With this schedule sludge is removed from each primary tank once in four hours, normally at 80 gal per min with two pumps operating. With five primary digesters in service, the total pumpage required to keep up gas production is three or four hours per day for each primary, compared to two or three hours during the winter months. Volatile solids varied considerably, averaging 69% for February and 51% for June, when excessive rainfall caused "washouts" in the sewer system. In general, maximum percentages of volatile solids in the raw sludge occurred during the colder months. Two 4-in. single-acting sludge pumps in each of four sludge control houses normally pump into adjacent digesters.

DIGESTERS PLACED IN SERVICE

There are five primary digesters with concrete roofs, heated with 5 circumferential pipe coils $1^1/_2$ in. in diameter; and three secondary digesters, not heated, with floating gas holders of 60,000-cu ft capacity each. All digesters are 90 ft in diameter. The primary tanks have side depths of 20 ft, while the secondary digester walls are 23 ft in height. The capacity of each digester is 1,000,000 gal, so that the total capacity is 6 cu ft per capita for a population of 170,000.

It should be noted that provision for the digestion of garbage solids has been a factor in determining the required digestion capacity—approximately one-third of the total having been added with the garbage-grinding plant. Transfer of sludge from primary to secondary digesters takes place when raw sludge is pumped to a primary tank. Piping is so arranged that sludge can be transferred from any primary to any secondary tank and vice versa. Re-circulation in the same tank can also be secured by pumping.

VIEW DIAGONALLY ACROSS PLANT
Left Foreground, Aeration Basins; Center, Eight Secondary Clarifiers; Right, Sludge Drying Beds; Background, Three 60,000 Cu Ft Gas Holders on Secondary Digesters

Raw sludge pumping was started on August 25, 1940, two days after the plant was placed in operation and was continued until April 1941, before any sludge was drained to the drying beds. The several primary digesters were placed in service without any trouble. At the start these contained about 5 ft of ground water, which had a pH of 7.3 and was used by the contractor to test the tanks for watertightness. At this time a 7,000-cu ft per min blower was in service on city gas to supply heat for the digesters. Two digesters were filled first and passed through the normal fermentation and solid periods of digestion, the pH being controlled by the addition of hydrated lime.

Daily checkings were made and lime added, usually twice a day in the amount of 100 to 200 lb. Stabilization of digesters occurred at a pH of 7.1 and this has since remained constant. The manholes on the digesters were left open and gas produced before the tanks were filled was allowed to escape. On October 8, one of the tanks was opened to the gas header, manholes were closed, and the waste gas burner lighted. One day later the other tank was put in service. Daily gas analyses were made, and on October 26 the city gas was shut off, and the sludge gas used to pump sewage. Since that date no city gas has been used. A total of 12,150 lb of hydrated lime was used in conditioning the digesters. The average calorific value of the gas (12 samples over 8 months) was 658.9 Btu gross, or 610.2 net.

After seven months of pumping to the digesters without any drawoffs, the average percentage of solids in the various tanks, as of April 1, 1941, was as follows:

Digester numbers	1P	2P	3P	4S	5P	6S	7P	8S
Percentage solids	6.8	5.0	4.3	1.5	4.5	1.0	2.1	0.9

(P = primary; S = secondary)

Raw sludge pumping to the primary tanks is controlled by the amount of gas required for power and miscellaneous uses at the plant. The outside operators check the holders hourly, and if, in the early morning, they are near the upper limit of travel, sludge pumping is started on the basis of one hour into each primary digester with two sludge pumps. Then later in the day, if the holders show indication of lowering at a faster rate than usual, additional pumping is done. On the other hand, if all three holders are up against the stops, the waste gas burner is lighted to prevent a build-up in pressure and blowing out of the seals. At times the waste gas burner and all the unit heaters will be in service to relieve excess pressure. To prevent an excessive sludge blanket building up in the primary clarifiers, it is necessary at times to pump to the secondary digesters.

EAST END OF PLANT. RIGHT TO LEFT: AERATION BASINS (EAST END), AERATION CONTROL HOUSE, PRIMARY CLARIFIERS, GRIT CHAMBERS

Pump and Blower House in Right Background

PUMP AND BLOWER HOUSE IS SPACIOUS AND ORNAMENTAL

Gas production has considerably exceeded original estimates. In November 1940 for the first time it was produced throughout the entire month, and the average daily production was at the rate of 1.25 cu ft per capita per day. Oil dumped in the sewer system the latter part of December reduced gas production below the average. Since January 1941, the average daily production has been approximately 1.55 cu ft per capita.

FINAL STAGES OF TREATMENT

There are ten aeration tanks 300 ft in length by 30 ft in width, with an average water depth of 15 ft. Each basin is a complete straight flow-through unit, with individual piping, valves, and meters. Air is distributed through stationary diffuser tubes, 3 by 24 in., staggered on 16-in. centers on a steel header. This header, 12 to 6 in. in size, extends the entire length of each tank. Each aeration basin has a capacity of approximately 1,000,000 gal, or a theoretical capacity of 4 mgd per tank with a six-hour aeration period, not including return sludge.

Only four aerating basins have been in use since operation was started, with the exception of 19 days in August 1941. Air requirements are from 0.5 to 0.6 cu ft per gal of sewage. This insures a dissolved oxygen residual at the end of the aeration period of above 2 ppm, and has prevented bulking over the seasons of the year that the plant has operated. No bulking trouble occurred during the dry period in July and August.

There are eight final settling tanks, each 75 ft square, similar to the primary tanks, except that grease skimmers are omitted. The settling period is two hours at a 40-mgd rate. In cold weather, to avoid the formation of ice in tanks that are out of service, six of the eight tanks were operated part of the time. The settling period averaged 2.7 hours from November to August, and the amount treated averaged 827 gal per sq ft for the same period.

There are three centrifugal-type return sludge pumps with capacities of 3, 4½, and 7 mgd, manually controlled. Shortly after operation started, it was found that if the rate of return sludge was allowed to get as low as 25%, septic conditions would develop in the final settling tanks. The rate of return is maintained so that no sludge blanket is carried at the edge of the final settling tanks. The depth of the sludge blanket is determined by a conventional sounding rod carrying 3 bottles spaced for sampling at 6, 12, and 18-in. depths. Soundings usually show 6 in. of secondary sludge at the center of the tank and less than 6 in. at the quarter point.

GAS PRODUCTION IS ECONOMICAL

There are five gas engine units. Three 175-hp, 5-cylinder engines drive sewage pumps with capacities of 20 mgd each at a total dynamic head of 35 ft. Two 300-hp, 6-cylinder engines drive blowers with a capacity of 7,000 cu ft per min at an 8-lb pressure. One sewage pump and one blower are used ordinarily with routine operation.

The blower is operated at about 91% of capacity and furnishes air at a rate of from 0.5 to 0.6 cu ft per gal of sewage; any variation in quantity is due to variations in flow and not to any change in engine and blower speed. With normal gas production, it has been possible to operate almost continuously since January 1941, with sludge gas furnishing power for sewage pumping and aerating. Almost $4\frac{1}{2}$ million cu ft is used per month for power and heat, including that used for heating hot water for the shower rooms and laboratory; this has a commercial value of about $1,750.

LOOKING WEST FROM ROOF OF PUMP BUILDING, OVER GARAGE TO SECONDARY DIGESTERS—MAIN PART OF PLANT TO RIGHT

Heat from the jacket water of the gas engines and exhaust gases takes care of heating the digestion tanks and the main building, as well as the shower and locker room and tool room in the garage building. In the summer the heat exchangers are by-passed. It has not been found necessary to use the heating boilers except for a short time when the plant was first placed in operation. No operating expenses are charged against the engines in computing the value of the sludge gas, for whether gas is purchased or produced at the plant the same operating personnel is required, and there would be no difference in oil and grease requirements. The total indicated savings are conservative in that a round figure of 600 Btu was used for the sludge gas whereas the average was 610. Gary's experience in gas-engine operation is only one of many which demonstrate the economy of using sludge gas as a source of power.

EFFECTS OF CONTRIBUTORY WASTES, GOOD AND BAD

Industrial wastes have presented no operating problem. One industry dumps about 6,000 gal of ferrous sulfate per week, having an acidity of 5.2% and 7.3% volume ratio expressed as total iron. This is a pickling liquor from a wire and bar mill. Grab samples taken as this liquor passed through the plant show total iron content (ppm) as follows: raw sewage, 310; clarified sewage, 160; mixed liquor, 140; and final effluent, 85. These are only approximate averages and vary with the rate of flow when dumping occurs.

There is a noticeable increase in clarification efficiency over the 24-hour period when the iron is passing through the plant. The average percentage reduction of clarified to raw sewage by months varies from 25 to 58, while on days on which the iron was passing through the plant, reduction has been as high as from 75 to 89%. The pH in the raw sewage drops from an average 7.1 to 6.9 as a result of the acid pickling liquor.

Waste oil interrupted the treatment when on December 20, 1940, oil from a heat treatment process was discharged into the sewer system in sufficient quantity to cover the four primary clarifiers with a fluffy black scum about 1 in. thick. On December 27 another charge, half as great, was received. The effect on the sewage treatment was felt within 24 hours. Gas production dropped from an average of 136,600 cu ft daily to approximately 80,000 cu ft for a period of three weeks. Dissolved oxygen in the mixed liquor dropped from an average of 7 ppm to 0.66 ppm.

Oil-coated sludge particles in the secondary clarifiers, having a low specific gravity, carried over the effluent wiers so that the removal of solids for complete treatment got as low as 54%. Publicity in the local newspaper regarding the oil dumping apparently cleared up this trouble.

LATER GARBAGE TREATMENT PLANNED

A garbage grinding plant was included in the sewage treatment plant for two reasons: first, because it is the duty of the sanitary district in Gary to provide a plant for the destruction or disposal of garbage and to operate such plant in connection with sewage disposal works; and second, because the operation of such a plant will increase the gas production at the treatment plant to sufficiently run all the motor-driven pumps and equipment at the plant, thereby permitting complete self sufficiency in the matter of power. The garbage plant cost approximately $65,000 and its operation is estimated to have a potential power equivalent of from $13,000 to $19,000 a year. As yet the garbage plant has not been placed in operation because permission has been secured to dump all wastes in a so-called sanitary fill to raise the grade of a large area of swamp land. Thus all waste material is collected simultaneously and no special equipment is required. Four load packers are in use; later these will be transferred to the sanitary district, and separated garbage will be collected for disposal through the grinding plant.

This plant is equipped with hoppers and conveyors leading to two grinders with rated capacities of 10 tons of garbage per hour. The expected annual average is approximately 23 tons per day, reaching peaks of probably 75 tons during the summer months. It was estimated that adding this quantity of ground garbage to the sewage would require some increase in the volume of air, a considerable increase (probably 35 to 50%) in the volume of sludge digestion space, and some increase in the sludge bed area; also, that the volume of gas from combined digestion would be approximately double that from sewage solids alone.

Negotiations are under way to provide for some experimental work to test out these estimates. Beginning about June 1, when green garbage will be heavy, we expect to arrange for the delivery to the plant of one or more truck loads of garbage daily, and we are confident that the showing made will be worthy of attention.

The operating personnel of 23 employees is under the direction of Superintendent William Mathews, who was resident engineer of construction for the consultants, Alvord, Burdick and Howson, of Chicago. A classification of employees shows one assistant superintendent, two chemists, a clerk, one janitor, one chief operator, 4 pump and blower house operators, 4 outside operators, 2 maintenance men, 2 ground men, and 2 laborers. In addition, 2 traveling operators take care of a separate Imhoff tank plant and the pump stations.

Many of the data, including the tabulation of operating results, are from Mr. Mathews' reports. Although the final operating procedures may be somewhat changed, the results obtained so far are indicative of what may be expected. This experience has demonstrated that each part of the sewage treatment plant functions properly, in the manner for which it was designed.

Evolution of Tremie-Placed Concrete Dry Docks

Especially as Bearing on the New Design for Philadelphia—Abstracted from an Address Before the March Meeting of the Philadelphia Section

By F. R. HARRIS, M. AM. SOC. C.E.
REAR-ADMIRAL (CEC) U.S. NAVY, RETIRED; NEW YORK, N.Y.

THESE notes on the development of the design procedures for the two large graving docks at the Philadelphia Navy Yard constitute a valuable contribution to the literature now available on the design and construction of such important works. The particular type of design and the construction procedures described by Admiral Harris are a development for which the engineering world is indebted to him. Too much emphasis cannot be placed upon the importance of this development in permitting the construction of huge graving docks with the utmost expedition.

A case in point is the great dry dock at Pearl Harbor. The first dry dock built there is very much smaller than the one recently completed. It took some six years to build the first by a floating caisson method; the body of the second was constructed in 20 months—one year ahead of schedule and ready to take a ship some two weeks prior to the attack on Pearl Harbor by the Japanese. One of the larger ships that had suffered damage was docked here two days after the attack. Similarly, the expeditious completion of the dry docks at Norfolk and Philadelphia will contribute materially to our war effort. Admiral Harris is entitled to every credit for these achievements.—

BEN MOREELL, M. Am. Soc. C.E., Rear Admiral (CEC), Chief of the Bureau of Yards and Docks, U.S. Navy.

A "DRY DOCK" is what its name implies—a dock which can be unwatered or made dry. The generic term "dock" means an enclosed basin into which vessels can be brought for layup, repair, loading, or unloading. Of course, no underwater repair work could be done in such a dock, which is normally a "wet" dock. If it can be made "dry" and the water removed, the hull can be exposed.

There are two kinds of dry dock. The first is the graving dock, the name of which comes from the word "grave"—a hole in the ground. This is a basin which excludes water; that is, it has practically tight walls, or sides and head, and a closure gate so that the water can be removed by pumping. The second type is the floating dock. Into this a vessel can be brought and then both dock and ship can be raised above the water surface. Such raising can be done in the case of smaller docks by hydraulic lifts or hoists, but is done for large docks by pumping out the interior, in which case buoyancy lifts both dock and vessel.

This paper is concerned primarily with graving docks and principally refers to the two large ones at the Philadelphia Navy Yard. These are graving or shipbuilding docks, that is, graving docks which are to be used for shipbuilding. One of them is practically completed, and the other is well under way.

MANY DIFFICULTIES EXPERIENCED

When the early graving docks were built, ships were smaller, had a shallower draft and an underwater shape that made possible the use of shorter, narrower, and shallower docks. Many of these were only completed after years of effort. Ten years was not an unusual period.

It was not infrequent for two or more contractors to try and to fail before one finally succeeded in completing the work—always at a greater cost than had been expected. In fact, the past history of graving dock construction is strewn with the wreckage of contractors, expensive litigation, and other types of disaster, including even serious collapse of the dock itself. Instances might be cited of actual abandonment of the work because it was considered either too costly to complete, or even impossible. With the increase in the size of ships, their greater width or beam, and their far greater depth or draft, the old methods of construction became increasingly difficult.

ADAPTING THE TREMIE METHOD TO THE CONSTRUCTION OF DRY DOCKS

It can readily be seen that digging a hole at tidewater some 60 or 70 ft below the water surface and some 1,000 ft long and over 150 ft wide, is a hazardous undertaking, difficult to estimate. Also, if the enclosing basin can be built under water, and without having to exclude the water, or if it can be built above the water and lowered into place, much of the hazard and uncertainty will be eliminated. The tremie method seeks to solve some of the difficulties.

It was first applied by the writer in 1927 to the outshore end of a graving dock built for the Robins Dry Dock and Repair Company in Erie Basin, New York (Fig. 1). The outboard end of this dock projected into the open water, where the subsoil or terminal moraine

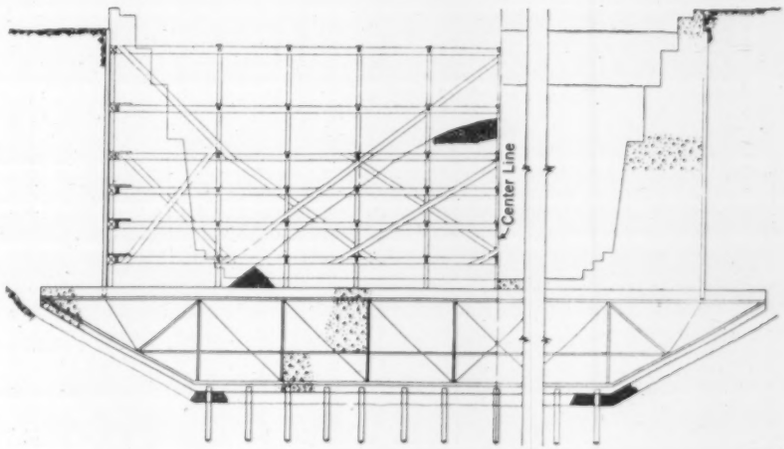
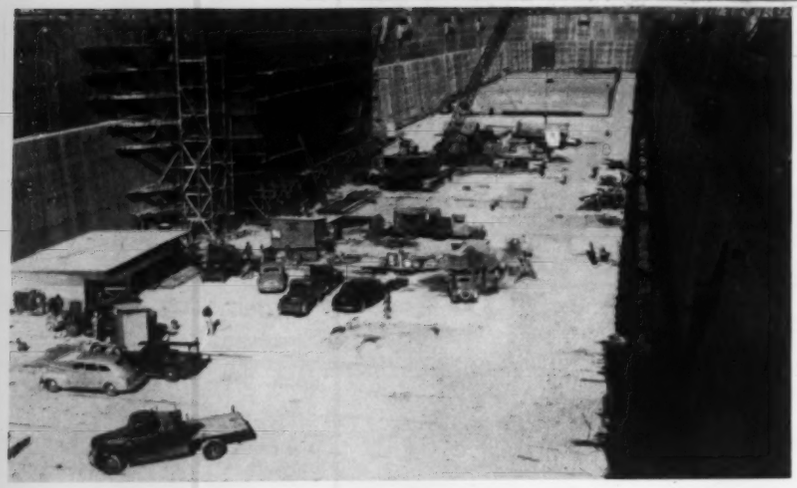


FIG. 1. TYPICAL CROSS SECTION OF ROBINS DRYDOCK NO. 1



LOOKING INTO LARGE DRY DOCK ON WEST COAST NEARING COMPLETION, AS OF JANUARY 1942

Dark Structure on Opposite Side Is Steel Caisson Gate Being Assembled and Welded

consisted largely of a very fine running sand in which boulders were embedded.

The tremie form units were placed on the subgrade, which had previously been prepared with a gravel or broken stone bed, and the concrete was poured within in one continuous operation by means of tremie pipes. Prior to concreting, steel sheet piling was suspended along the back line of the side walls so as to embed the lower ends in the tremie concrete. This sheet piling was braced across the proposed dock by timber wales and braces embodied in a series of cribs. The lower tiers were built on shore and launched in the water, and then the upper tiers of wales and braces were added.

Backfill was placed on the shelf behind the two lines of sheeting after the tremie concrete had set. Then gravel ballast was placed in a pile at the center for added weight, to counterbalance the hydrostatic pressure, and the cofferdam was unwatered for completion of the dock in the dry. As the side walls were built up, the gravel ballast was gradually removed for use as coarse aggregate in the wall concrete.

The cost of this dock was well within the original estimate. It was completed and in use in less than two years.

DEVELOPMENTS IN HAWAII

At Pearl Harbor the first graving dock was built by the sectional method—that is, by floating in sections and lowering them into place. This was adopted after the conventional method of a braced sheet-pile cofferdam had failed. This experience indicated that any additional graving docks built there by that method would involve not alone great cost and a much longer construction period than could be allowed, but also, on account of the increased size and depth required, grave doubt that the very complicated equipment required would be practicable.

On account of the success with the outboard end of the Robins dock, the tremie method was adopted for the second dock at Pearl Harbor, designed by the Bureau of Yards and Docks with the assistance of the writer. The scheme of placing the bottom by tremie was adhered to but the plan was changed somewhat (Fig. 2). The side walls were built in the dry by sections in narrow cofferdams transversely, one for each wall, so that initially only the water in the cofferdams was removed. This method permitted the retention of the full water head in the central part until the side walls were completed, and made unnecessary the long, complicated transverse bracing and the stone or gravel ballast. Recesses were provided in the top of the slab for placing the sheet piling to form these cofferdams.

Steel H-piles were driven in the subsoil (Fig. 2), and partial reliance was placed on these to resist uplift when the dock was unwatered. The pile anchorage was considered as limited to 30% of the submerged soil weight of the prism of earth surrounding the piles. The dock was not unwatered until all the walls had been completed and backfilled, so that after the initial unwatering the combined weights of (1) the floor slab and side walls, (2) a small percentage of the frictional wedge on the side walls, and (3) 30% of the theoretical uplift value of the piles, were counted upon to resist the upward hydrostatic pressure. The floor spanning between the walls was designed to transfer the upward hydrostatic pressure on the bottom over to the side walls; the necessary reinforcing for this had been added to the tremie truss steel before the trusses were lowered to the bottom.

The steel and concrete are stressed to the usual allowable limits during the cofferdam stage and also when the dry dock is finished, taking into account the action of the steel H-piles. As a precaution against the possibility that these piles could not be driven to the designed depth, and thus might not safely afford the anchorage required, the dock was also designed for the condition of no piles acting, in which case stresses were allowed to run to just within the elastic limit. To counterbalance the lack of the pile anchorage effect, the full frictional wedge of the backfill against the side walls was included in the computations.

This method was entirely successful, especially as regards expedition and safety, but it was at once discovered that the placing of the walls in the dry, using steel sheet-pile cofferdamming, complicated the work and delayed its completion. This was especially so since the plans called for ordering just enough sheeting for a limited number of side-wall cofferdams and then, on completion of the concrete wall, for removal of these cofferdams and

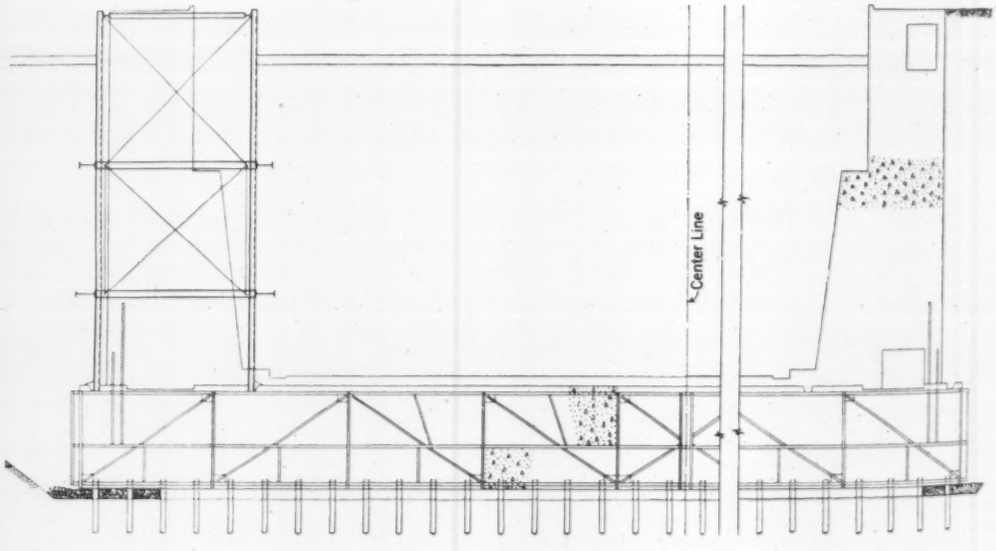


FIG. 2. TYPICAL CROSS SECTION OF A DEEP DOCK

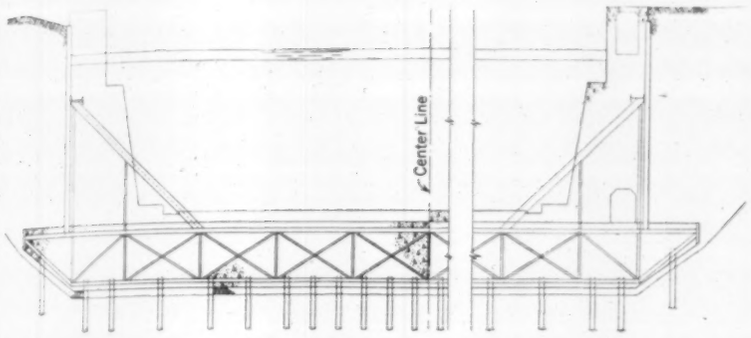


FIG. 3. TYPICAL CROSS SECTION OF A SHALLOW DOCK

their re-use, in all, three or more times. This method also involved the placing of the connections between wall sections. Even so, the dry dock was completed in a little over two years.

STILL ANOTHER MODIFICATION

Shortly thereafter smaller, shallower docks (Fig. 3) were designed for Pearl Harbor and Mare Island, with a further improvement in the method. Here the dimensions of the dock were such that a single line of sheet piling could be used above the tremie floor with one line of support, namely, a waler held by diagonal braces embedded at intervals in the tremie floor. The diagonal braces and waler were part of, and lowered with, the main tremie truss forms. The steel sheeting was suspended from the waler before the tremie concrete was poured, and its lower end, as in the earlier work in Brooklyn, was embedded in the concrete to seal it against leakage and to take its lower reaction. Across the entrance and around the headwall this same type of braced sheet piling was used.

The tremie slab extended beyond the steel sheeting at the side in order to form a shelf to pick up the weight of the backfill. This was necessary to provide sufficient weight to offset the hydrostatic uplift under the dock floor during the cofferdam stage, prior to completion of the side walls. The diagonal brace (Fig. 3) not only supported the sheet piling but served to reduce the span length of the floor slab during the cofferdam stage. Therefore, with the use of the shelf at the back of the sheeting and the diagonal brace on the side, the slab thickness required during construction was no greater than that required in the finished section.

Piles were also driven under these docks, and partial reliance was placed on them for protection against uplift. This design permitted backfilling against the steel sheeting within a short time after the tremie concrete was poured. After backfilling, the dock could be unwatered, for the construction of the side walls and final floor.

This design resulted in a very simple, safe, and expeditious construction procedure. The backfilling, since it was against the sheet piling, could be undertaken at a very early stage of construction, thereby making it possible to complete some of the crane track and other structures adjacent to the dock prior to completion of the side walls.

When the first Philadelphia dry dock was proposed, initial designs showed that an extension or improvement over the previous methods by the use of tremie walls would result in a more economical design and a more expeditious construction procedure. The use of side-wall cofferdams as at Pearl Harbor (Fig. 2) proved to be a slow and hazardous operation, and the simple method employed for the twin destroyer docks (Fig. 3) could not be used without thickening the floor and introducing extensive and impractical bracing supports for the sheet piling.

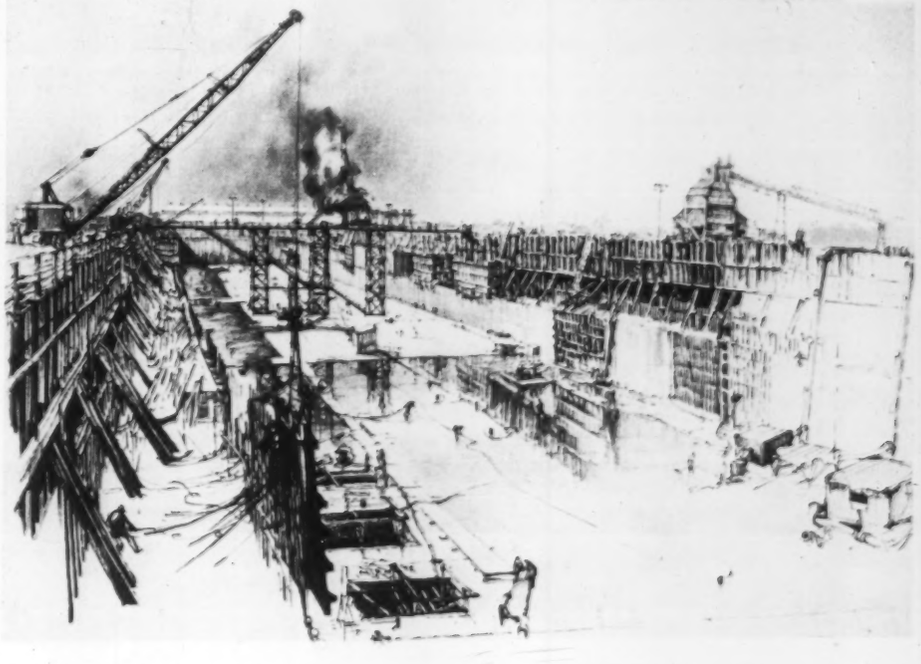
At Philadelphia, as in the other tremie constructed jobs, after the bottom was prepared with a gravel bed 2 ft thick, steel H-piles were driven below subgrade (Fig. 4); but here they were for the purpose of carrying the loads of the dock through a soft layer at subgrade into a firm stratum below. The downward loads occur when the dock is flooded or when a ship is in dock.

The steel tremie floor forms, extending for the full width of the structure, were placed on the gravel bed in the same way as in the other jobs, and the blocks were poured up to the inside line of the tremie walls. After the concrete had set sufficiently, the tremie wall forms were set on the floor forms, whereupon the walls were poured from subgrade to the top of the forms. Prior to this, however, a line of sheet piling was suspended from a continuous horizontal waler supported above the top of the wall form by an A-frame in an arrangement similar to that of the shallow dock method. Upon completion of the tremie walls, backfill was placed, and after this the dock was unwatered for completion in the dry.

In order to make the appearance of the inside comparable with that of docks whose walls are built in the dry, a dry concrete lining was placed on the inside of the wall forms as well as on the floor. The finish wall line therefore did not have to depend upon the setting alinement of the wall forms, nor was the texture of the final face that of the tremie-placed concrete.

The reason for using tremie-placed walls was to complete as much of the concreting as possible prior to the backfilling and unwatering of the site, thereby advancing the completion date. Another advantage was that by lowering the water in the dock area to just below the top of the tremie walls, it was possible to complete the top of these walls and the backfill before pumping out the rest of the water, which would act as ballast on the floor, if required.

The original design at Philadelphia contemplated leaving some water ballast on the floor until the walls were topped off. But during the construction a recomputation showed that there was sufficient weight in the floor



CONCRETE WALL CONSTRUCTION AT NEW EASTERN DRY DOCK

At Left a Large Form Panel Is Being Guided Into Place. From a Pencil Sketch by Lili Réthi

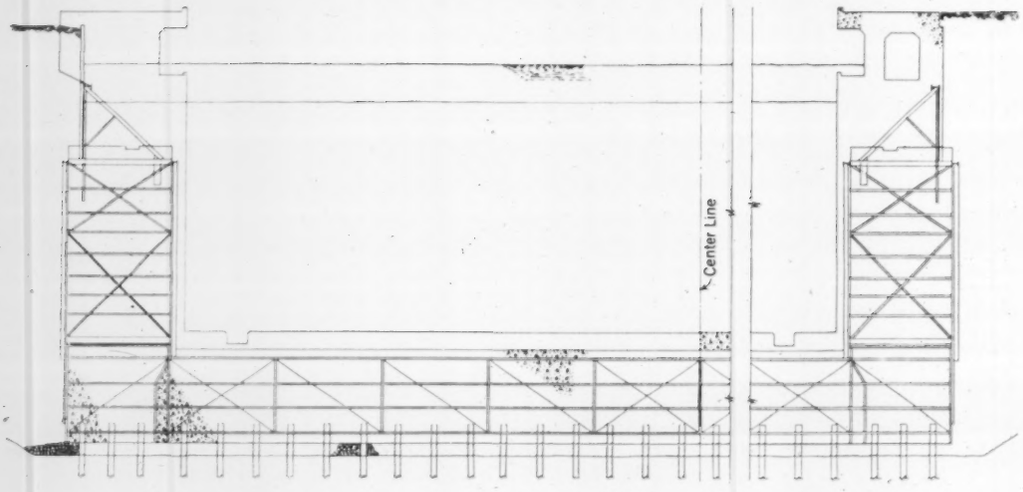


FIG. 4. TYPICAL CROSS SECTION OF PHILADELPHIA DRYDOCK

slab, and sufficient pile anchorage to be counted on, to warrant complete unwatering initially.

BASIS FOR DESIGN

In designing this dock, the dimensions of the structure and the amount of reinforcing steel were determined by considering four main conditions, as follows:

1. The cofferdam condition in which the tremie floor and wall are poured, backfill is placed, and the dock pumped out. For weight to resist upward hydrostatic pressure, there is taken into consideration the weight of the structure, the uplift value of the piles, and a small percentage of the frictional wedge of the backfill against the side walls. Under this condition of loading, and of course taking into account the active pressure of the backfill against the side walls, the stresses in the concrete and reinforcing steel were permitted to exceed the allowable by 20%, because the conditions were only temporary.
2. The condition of the finished empty dock, with walls and floor lining completed. Two cases are considered under this condition. In one, the piles act to hold the structure down but the frictional wedge of the backfill on the side walls is neglected; in this case the stresses are kept within the normal allowable. The other case assumes no anchorage effect of the piles but the full effect of the frictional wedge acting on the side walls; in this case the stresses are permitted to exceed the allowable up to just within the elastic limit.
3. The finished dock full of water, in which case the foundation piles are subjected to their greatest downward load.
4. The finished dock unwatered, with a ship of maximum tonnage in it. The conditions here are similar to those of (2), except that the weight of the ship is concentrated at the center line on the keel blocks and on the side blocking. In this case piles in local areas are subjected to maximum loads; and stresses in the steel and concrete are kept within the normal allowable.

ADVANTAGES PROVED BY EXPERIENCE

The design adopted for the first of these two Philadelphia dry docks has been used with marked success. This work showed that it is possible to build these large graving docks, ready for use, in less than two years. The same design was used for another shipbuilding dry dock at Norfolk, Va., which is being built concurrently with the Philadelphia one, likewise very successfully. The same design has been adopted for the second dock at Philadelphia and for docks at the Brooklyn Navy Yard. At Brooklyn, the design will be exactly like that used for the first dock at Philadelphia; for the second dry dock at Philadelphia modifications have been made to further expedite the construction. One was to raise the top of the tremie concrete wall to its maximum wherever possible, about mean tide, and to raise the form above mean high water. This will permit the construction of the upper part of the wall in sections at low tide without waiting for the unwatering of the dock. The other modification was to make the line of the inside face of the tremie concrete wall the finish line, and to remove the tremie wall form on the inside, after unwatering, thereby eliminating the wall lining and saving time. In the most recent dock now under construction, the design contemplates the use of removable under-water side forms, with a view to saving the corrugated steel siding.

In general, the tremie method of construction for dry docks has proved a great time saver and has made possible the completing of the largest types of graving docks in about two years where formerly they took much longer. But this type does involve large preliminary expense in plant and in planning the work, especially in connection with the under-water pile driving where this is required, and the weight-handling appliances to lift and place the tremie trusses. On the East Coast docks, including the very earliest one at the Robins plant, floating derricks have been used, while on the West Coast, in the Hawaiian Islands, and at Mare Island, shore-supported gantries have been chosen.

OTHER PROCEDURES ALSO USEFUL

This paper would not be complete without stating that where foundation and other conditions warrant, other methods of construction are equally expeditious and less complicated. Such methods are a more or less recent development and involve the pre-drainage of the site either by wellpoints or deep-well pumps. The writer's designs using wellpoints have been constructed successfully at the graving docks at Callao, Peru, and at San Juan, Puerto Rico. Under the Bureau of Yards and Docks, the design using well points was successfully used at San Diego, Calif.—prepared by our organization in association with Moran, Proctor, Freeman and Mueser; Parsons, Klapp, Brinckerhoff and Douglas; and Fay, Spofford and Thorndike. Construction by deep-well pumps was adopted at Long Beach, Calif., under the Bureau's direction, with the writer as a special consultant.

These other methods are mentioned to show that the tremie method constitutes no general panacea for constructing graving docks. The method to be employed must be based on a searching examination of the proposed site, including thorough subsoil exploration and tests on soil samples for both compressibility and permeability, and on a general and very broad knowledge of all the circumstances involved in this especially difficult foundation problem.

Ohio Analyzes Its Highways

By JOSEPH R. SMART, ASSOC. M. AM. SOC. C.E.
ENGINEER-ECONOMIST, STATE DEPARTMENT OF HIGHWAYS, COLUMBUS, OHIO

KNOWLEDGE is power. In the case of highway studies, data intelligently collected provide the background for judicious planning for the future. Ohio has been accumulating such knowledge for 40 years, but more particularly since 1936 by means of its Highway Planning Survey. The report of this work is here summarized. It shows the physical features of all the roads in the state, the peculiarities of traffic, the economics of highway use and income, and the direct and indirect dividends that can be secured from road maps. Other states can doubtless profit from Ohio's experience.

OHIO, like the other 47 states, has been conducting a systematic study of its roads. Some of the findings during the past six years have widespread engineering value. The agency responsible for the study is known as the Ohio Highway Planning Survey, a component part of the State Department of Highways. From this study a tremendous number of data concerning motor traffic, highway economics, and the physical assets of the state's highway network have been accumulated.

These data are recorded in seven large volumes and on over one million punched file cards. The information is thus available in detail to highway and safety engineers and to others closely associated with the highway industry as well as to the general public. To make the information more accessible, a concise report has been issued. The report deals specifically with Ohio, but as this state is quite typical of a group of states, and as many comparisons with other states are made, it is of general interest.

It is not intended as a detailed report, but as a "show window" of the accomplishments of the survey. The belief is that those interested, after reading the concise report, will avail themselves of the wealth of detailed material on which it is based even more than they have in the past. The report is written in non-technical language easily understood by anyone, whether or not he has intimate knowledge of highway problems. Some of its more important findings will be reviewed.

ROAD INVENTORY COMPILED

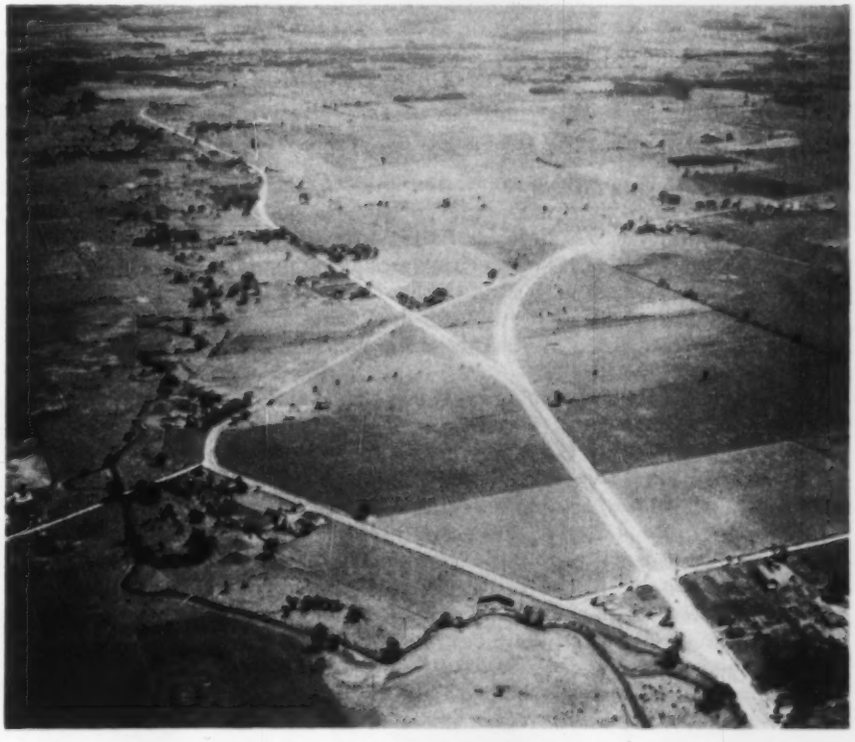
The first step of the survey was an inventory of the highway network. Every public road in the state showing any evidence of travel or maintenance was catalogued as to length and other details. Strangely enough, before this survey no one knew the exact total mileage of roads in Ohio. The generally accepted figure of 85,000 miles was found to be about 2,500 miles too much. Of course, the exact length of the state system was already known. But the mileage of county and township roads previously believed to be in existence exceeded that actually found by an amount equal to a length of road from Ohio to the Pacific Coast.

The survey also revealed the absurdity of the periodic agitations to "make Ohio's roads uniform." These campaigns usually point out that certain other states have "ribbons of pavement" of uniform width and quality extending completely across them. Study of a traffic flow map of Ohio shows that no highway in the state justifies such uniformity.

A highway of uniform width and quality should have approximately uniform traffic density for its entire length. If it does not, it is overdeveloped in some places or underdeveloped in others. Underdevelopment is obviously dangerous and expensive to the motorist. The overdeveloped sections ordinarily do not receive adverse criticism, but it should be remembered that, with funds limited as they are, every overdeveloped section of road means that there is an underdeveloped section elsewhere.

PECULIARITIES OF TRAFFIC

In a state as highly industrialized as Ohio we might expect a large percentage of the vehicles on the road to be commercial. It was found that about one-half of the passenger-car travel was for business. About 10% of all motor vehicles registered in the state are commercial. Large trucking units are conspicuous on the highways, especially to the motorist who happens to be in back of one on a long hill; but numerically they are insignificant. Only 0.64 of 1% of all vehicles observed in Ohio had a total weight, with load, in excess of 12 tons.



EXAMPLE OF SHORTENING A MAIN ROUTE TO REDUCE CURVATURE
A Simple Solution, Which Nevertheless Required Detailed Study

ELIMINATION OF A TRIPLE THREAT
Realinement Overcomes Restricted Sight Distance, Sharp Curve, and Inadequate Bridge

Of the entire rural highway network of Ohio, 10% is paved, 75% surfaced, and 15% unsurfaced. Nearly all the unsurfaced mileage is on obscure township roads. The average Ohio driver probably would have difficulty in recalling the last time he used an unsurfaced road. It is gratifying to learn that of each 100 rural dwellings in Ohio, 94 are served by surfaced roads. This is a higher percentage than for any other state on which information is available. It is clear, therefore, that the objective to "get Ohio out of the mud" has actually been attained.

While most of Ohio's roads are now surfaced lightly or otherwise, many miles have been inadequately constructed for the traffic they must sustain. Further, thousands of miles are too narrow, have excessive gradients and curvatures, and are made hazardous by short sight distances. The miles of inadequate road are carefully tabulated in the inventory.

IMPORTANCE OF THE STATE SYSTEM

A preponderance of rural traffic is found to patronize the state system, which, with only 20% of the mileage, carries 77% of the traffic. Yet the state system is allotted only 36% of the receipts from imposts on motorists—this is the fourth from the lowest record in the nation. Such imposts include motor fuel taxes, motor-vehicle license fees, fines, motor carrier fees, and chauffeur permits.

It is obvious that the spending of such a small percentage of funds on state routes, and relatively large sums on county and township roads, is against the interest of the rural dwellers who are supposed to benefit by this allocation. Residents of unincorporated areas of Ohio drive $2^1/_2$ miles on state routes for every mile on county and township roads combined. Clearly it is of no advantage to drive over a mile of local road maintained better than the traffic justifies and then to drive $2^1/_2$ miles on a state route starved for maintenance or improvement.

Then too, the orbit of travel of cars is much smaller than popularly supposed. The average car owned in rural Ohio gets only 94 miles away from home in the course of a year, while the average city car ventures 205 miles. The median passenger and truck trips are 6.5 miles and 7.1 miles, respectively.

The cost of driving over a mile of highway is the sum of two expenditures—the cost of operation of the vehicle and the proportionate cost of the construction and maintenance of the road. A properly designed highway will provide adequate transportation, keeping the total of these two expenditures at a minimum.

A wide smooth highway with only a few dozen cars traversing it daily allows a car to be operated at minimum cost. At the same time the motorist's tax must be high to pay for the road. At the other extreme, a rough, muddy road costs little to maintain but the required gasoline consumption is high, irreplaceable tires are soon worn out, dust grinds engine bearings, and the jolting quickly shakes the car to pieces.

The economical highway is the one constructed properly for the traffic it must bear. The great, smooth highway with thousands of cars traversing it daily, costs relatively little per vehicle-mile for construction and maintenance and allows cars to be operated cheaply. There is no question but that it is economical. The little-used gravel road costs more for car operation, but if it were improved beyond justifiable limits, the cost of the improvement and maintenance per vehicle-mile would more than overbalance the saving per mile in car operation. Here the cheaper road is the economical road.

Such considerations point to the value of Ohio's Highway Planning Survey. It has collected data on vehicle-miles of travel on the state's highway network to the

A RELOCATION THAT INVOLVED SEVERAL COMPLICATIONS
It Eliminated an Obsolete Bridge, a Railroad Grade Crossing, and Sharp Curvature

end that each section of the system may be designed to fit its particular needs.

TAXES ON AUTOMOBILE USERS

Nineteen states, among them Ohio, tax gasoline at the rate of 4 cents a gallon, including the liquid fuel tax of 1 cent a gallon. Only ten states have a lower rate. Even with the tax, Americans have enjoyed cheap gasoline. In contrast, in January 1939, when motor fuel was obtainable by civilians in the respective countries, gasoline cost the equivalent of 60 cents a gallon in Germany and 81 cents in Italy.

Average passenger-car license fees in Ohio are $8.89, a few cents more than the national average. Automobile license fees in the United States make an interesting contrast with those in some other parts of the world. For example, in England in November 1939 the license fees for privately owned passenger cars comparable to our three most popular makes averaged the equivalent of over $150 a year.

It is well known that automobile users furnish most of the funds for the construction and maintenance of the state highway system and county roads, and that they contribute heavily toward township roads and city streets. It is not so generally recognized that they carry a heavy share of the taxation for the general welfare. This taxation is through sales taxes on new and used cars, car parts, tires, and lubricating oil; through a gasoline excise tax of the Federal Government; and through many indirect taxes. These sales taxes amount to about one-fourth of the total sales taxes paid in Ohio. In addition, a tax of 1 cent a gallon, called the liquid fuel tax, provides the general revenue fund of the state with about $13,000,000 per year.

The amount of taxation derived indirectly from traffic is invaluable to the general welfare. Automobile manufacturers, service station properties, oil producers and refiners, and pipe-line companies all obtain the income which produce their taxes from users of the highways.

As good highways stimulate this source of income, money expended for their construction and maintenance is sound, hard-headed business sense. This must be true, for as good highways augment income by encouraging traffic, conversely poor roads impair these sources of general revenue.

MAPS PROVE INVALUABLE

Among the valuable results of the Highway Planning Survey are the surveys and maps prepared in connection with it. These maps show all the highways of each county, the almost obliterated roads twisting into the hills as well as the heavily traveled routes, with symbols indicating whether they are paved, surfaced, or unsurfaced. In areas outside municipalities, every house, business establishment, recreational center, transportation agency, church, and cemetery is shown by an appropriate symbol.

The principal purpose of the county maps was to show highways with relation to the other culture of the state. A study of a county map presents a complete view of the homes and businesses within the scope of influence of a proposed highway improvement. But the use of the county maps is far from being confined to highway planning.

Chambers of Commerce and city stores use these maps to study the communities within their spheres. The maps have shown utility companies where it would be profitable to extend telephone and power lines. Creameries and bakeries frequently obtain the maps for the purpose of establishing their routes, as do school boards for determining school bus routes. The board of health of one Ohio county uses the map to mark the houses where contagious disease exists. As all cemeteries are shown on the map, the Adjutant General of Ohio finds a complete set useful in locating and recording veterans' graves. The list of those using the maps is almost endless. The Planning Survey, using the county maps as a base, has prepared traffic flow maps for all of Ohio's 88 counties.

MODERN IMPROVED ALINEMENT AVOIDS TWO RAILROAD GRADE CROSSINGS AND SEVERAL BRIDGES, INCLUDING A COVERED STRUCTURE THAT PREVENTED VIEW OF TRAINS

Until recently these maps were distributed to all who requested them at cost. They are now obtainable only by accredited organizations or individuals, by order of the Department of War.

Since these Ohio studies were made, there has been a vast change in outlook due to the present emergency. However, the survey is more than a reflection of normal conditions. The information on the average length of car trips, average truck loads, taxes paid by motorists, and many other data are of vital importance to those endeavoring to predict the effects of the impending decrease in the use of automobiles due to war regulations.

Engineers having to do with highway data can doubtless utilize the findings. These and others seriously interested in highway problems may obtain the report, without cost, from the Ohio Highway Planning Survey, Department of Highways, Columbus, Ohio. A copy is on file in the Engineering Societies Library, 33 West 39th Street, New York, N.Y.

Toledo's New Lake Erie Water Supply

By GEORGE N. SCHOONMAKER, M. AM. SOC. C.E.
CITY MANAGER, TOLEDO, OHIO

WATER, a simple compound, is responsible for some of the engineer's major problems. With the growth of cities the matter of water supply has assumed a truly vital importance. Its quantity and quality are the concern of every city dweller. In the case of Toledo there has been great expansion in the water supply system since 1873, when it boasted a connected clientele of 12. To provide its present metropolitan population of about 330,000 with ample quantity and improved quality, an entirely new source was recently developed —Lake Erie. The various design and construction steps in the realization of this ambitious project are here described. This paper was originally presented before the February 4 meeting of the Michigan Section of the Society in Detroit.

IN considering Toledo's latest addition to its water facilities, it is hard to realize in what small beginnings the present development had its origin. The first water works system started operation in December 1873. It consisted of a pump station with an installed capacity of 10 mgd, $8^1/_2$ miles of distribution mains, and 12 connected customers. Water was obtained from Swan Creek and delivered unfiltered. The first year there was no revenue.

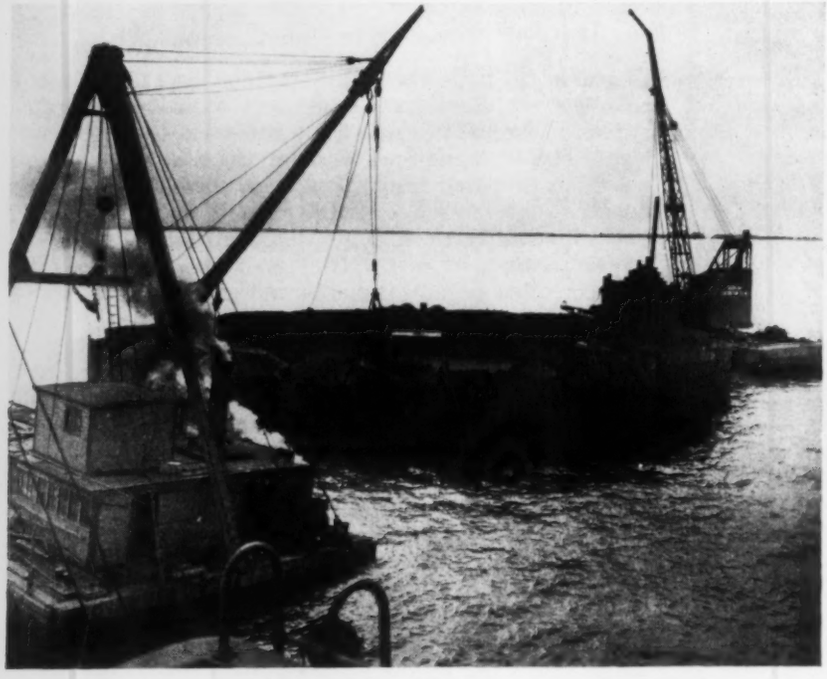
From that meager beginning the system has grown steadily. Improvements and additions were made from time to time until, in February 1910, the Maumee River Filtration Plant was put in operation to supply the first filtered water to the city. This system served, again with numerous extensions, until operation of the Lake Project was started. Our 1941 records show that there are 73,289 connections serving a total population of 328,000 in Toledo and environs. The average daily pumpage for 1941 was 40 mgd. The hourly pumping rate has at times reached a maximum of 91.5 mgd.

The nominal capacity of the Maumee River works is 56 mgd. The inadequacy of this supply compared with the ever-increasing demand for filtered water is the paramount reason why Toledo undertook a major improvement in its water works system in 1939.

The first serious consideration of Lake Erie as a source occurred as early as 1902 when engineering studies were made looking toward a new potable supply. At that time the cost of obtaining water from Lake Erie at so great a distance from the city could not be justified against the convenience of the Maumee River. The latter source was therefore chosen, with filtration, and the river filter plant was put in operation in 1910.

Acting upon the recommendation of two independent engineering reports, one in 1927 and one in 1937, the city decided by popular vote of a $3,600,000 bond issued in August 1938 to abandon the Maumee River works and to construct an entirely new system using Lake Erie as its source. This action assures Toledo of an inexhaustible supply, in quality much softer than the river water (about one-half the hardness), lower in bacterial content, more uniform, and consequently easier and cheaper to treat.

The first construction on the Lake Erie project started in April 1939. By June 1941, work on all contracts was declared substantially completed. By the end of 1941 all equipment had been tested and the plant was ready for operation. The project so constructed in approximately $2^1/_2$ years consists of the following major elements (Fig. 1): (1) intake, crib, and conduit; (2) raw-water, or low-service pumping station; (3) Lake Erie pipe line; (4) 80-mgd filter plant; (5) 35-mgd covered, concrete, filtered-water reservoir; (6) high-service pumping station; (7) 1.0-million gal elevated storage tank; and (8) 7 miles of large-diameter high-service trunk mains.



FILLING COFFERDAM CELLS FOR INTAKE CRIB IN LAKE ERIE
First Step in Constructing Concrete Crib Structure

INTAKE CRIB AND CONDUIT

Before fixing the final design for the Toledo crib, all the major intakes on the Great Lakes were studied with a view toward avoiding as much as possible the various difficulties experienced. The new Toledo Crib, we believe, incorporates all the desirable features and eliminates those that may lead to operating troubles. The new crib is located in Lake Erie approximately $2^1/_4$ miles offshore, northeast of Reno Beach, approximately 10 miles east of Maumee Bay, where the water depth is about 22 ft. The crib itself is an exposed concrete and brick structure, circular in plan. It has an external diameter of 100 ft at the base, with a central open well area 60 ft in diameter, in the center of which is the downtake shaft to the intake conduit. The crib structure extends some 42 ft above normal water level, affording two levels of rooms, the upper of which is fitted with living quarters for caretakers and workmen. Water is admitted

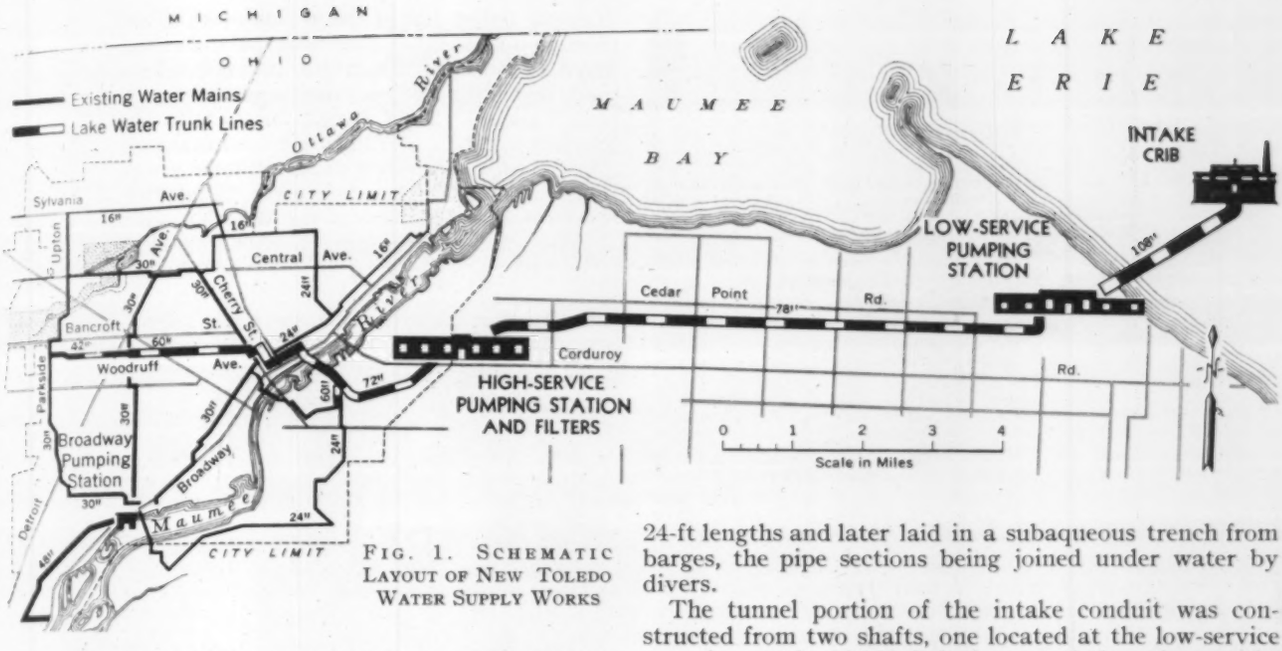


FIG. 1. SCHEMATIC LAYOUT OF NEW TOLEDO WATER SUPPLY WORKS

into the crib through 16 ports, each 10 ft square, located around the perimeter of the structure.

There are no bars or screens of any kind covering these ports, the object being to provide the greatest opening area possible to discourage formation and adhesion of frazil or needle ice which might tend to clog the intake ports during certain winter weather conditions. At the present maximum filtration rate of 80 mgd, the inflow velocity through the ports will be 0.10 ft per sec. This very low velocity is expected to reduce to a minimum the quantity of needle ice drawn into the crib by the intake current. All the raw water is screened at the low-service pumping station just ahead of the pump suction chambers, passing through bar and fine screens at that point.

Several means of communication between the crib and the shore were considered as to dependability, and as to initial and operating costs. The method finally adopted and now installed is a two-way radio-telephone system which provides contact not only between the crib and the low-service pumping station, but also between that station and the new administration building at the filter plant site. The system is the latest type of short-wave frequency modulation, radio-telephone communication equipment. A transmitter and receiving device are located at each point of communication. Consideration has been given to the future extension of this system to include a receiving set on Water Department service trucks for dispatching emergency orders to service men in the field.

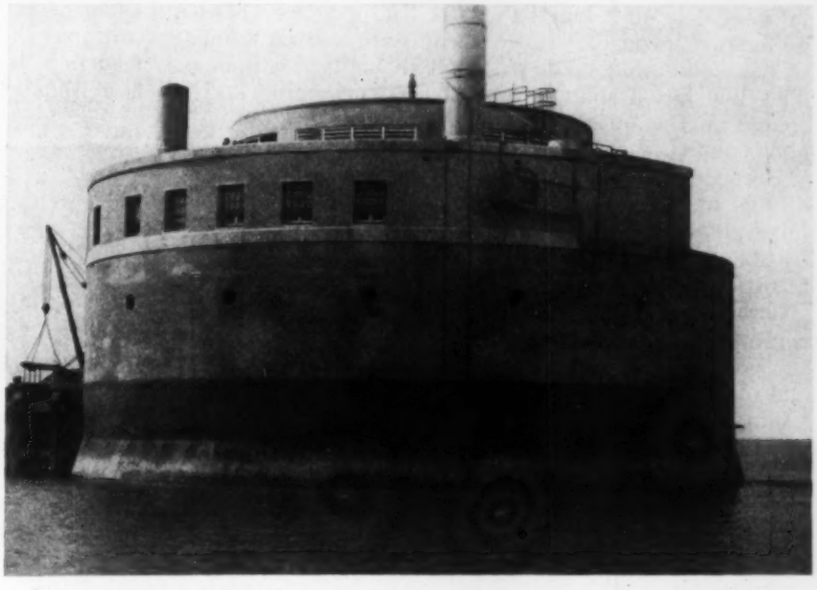
A gravity intake conduit, 15,500 ft in length, connects the intake crib with the suction well of the low-service pumping station. The lake portion of this conduit is constructed of precast reinforced concrete pipe. The land section, extending to a point 2,000 ft offshore, is a monolithic concrete tube constructed in tunnel, the two types of construction being joined where they meet to form a continuous conduit. This conduit is circular in cross section and 108 in. in diameter throughout its entire length. The reinforced concrete pipe section was precast in 24-ft lengths and later laid in a subaqueous trench from barges, the pipe sections being joined under water by divers.

The tunnel portion of the intake conduit was constructed from two shafts, one located at the low-service pumping station 4,000 ft inshore, and the other on the lake shore. The headings were each approximately 2,000 ft long, and it is of interest that they met within $\frac{1}{4}$ in. on line and within $\frac{1}{8}$ in. on grade. The joining of the tunnel and the precast-concrete pipe types of construction was accomplished under water by means of a specially fabricated telescoping section of precast pipe, the actual connection being made by divers while both the tunnel and the precast pipe were full of water.

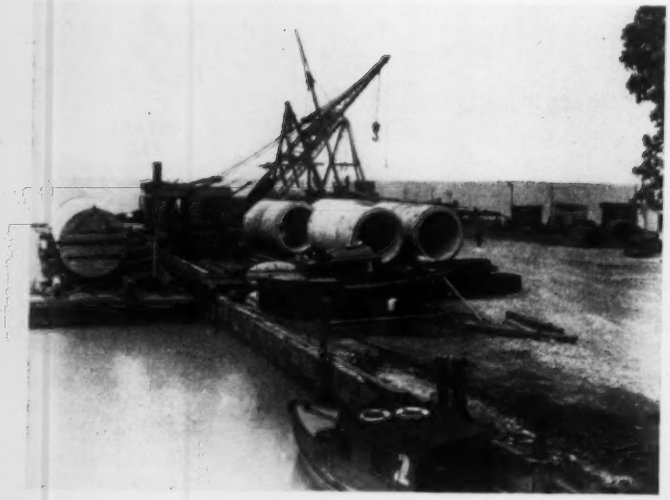
Leakage tests made on completion proved tightness against infiltration amounting to only 10% of the specified maximum tolerance, indicating a careful and thorough job. The entire tunnel and marine operations in connection with the intake conduit and crib were accomplished without any serious accident and without a single loss of life.

THE LOW-SERVICE PUMPING STATION

The low-service pumping station (Fig. 1) is located 4,000 ft inshore from the lake, approximately 13 miles



INTAKE CRIB IS 40 FT HIGH WITH 100-FT OUTSIDE DIAMETER
Steel Armor Plate 10 Ft Above, and 10 Ft Below Water Line Protects Against Abrasion



LOADING DOCK FOR 108-IN. INTAKE PIPE—TWO SECTIONS BOLTED TOGETHER WERE GENERALLY LAID AT ONE TIME

Double-Reinforced Pipe Sections Are Each 24 Ft Long, 55 Tons in Weight, 12 In. in Wall Thickness

east of the center of the city. The initial installation consists of four pumps arranged in two separate pits to avoid flooding and complete plant shutdown should a major pipe break ever occur within the pumping station. The pumps are horizontal, bottom-suction, centrifugal type, each driven by a variable-speed induction motor. The total installed capacity of the four pumps is 220 mgd. In the future, pumping capacity may be increased by replacing one or more of the present units with a unit of higher capacity.

Normally this station will operate on purchased electric power; however, two 628-kw diesel-engine generator units have been installed in the plant as an emergency standby power supply. The most modern electric control equipment in the form of metal-clad switchgear and bench-board type of panel has been installed, making possible the control of pumps and all principal valves from one central board.

The Lake Erie or raw-water supply line connects the low-service pumping station with the filtration plant. This line, 9 miles in length and 78-in. in diameter, is constructed of steel plate $^{9}/_{16}$ in. thick. The pipe was fabricated in 40-ft lengths and laid in open trench with an average cover of 8 ft. All seams are electric welded; all field joints were made with bolted-ring type couplings. This line has a spun bituminous enamel lining and is coated on the outside with bituminous enamel.

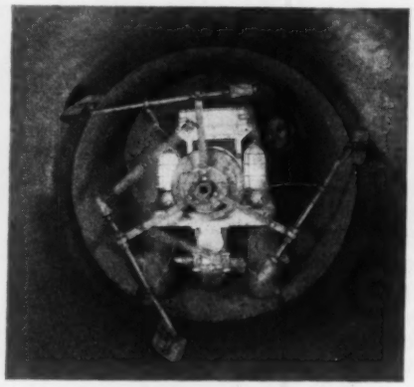
Because of difficult foundation conditions at the site selected for the filter plant, it was not economically feasible to combine the chemical and filtration buildings in one unit as is generally done. The filter building is a one-story structure which houses the reaction chambers, the entrance end of the sedimentation basins, and twenty 4-mgd filter units, making a total installed capacity of 80 mgd.

There are four reaction chambers, each equipped with paddle-wheel type flocculators, the chambers being built integrally with four sedimentation basins, each equipped with a straight-line sludge-collecting mechanism. A carbonation chamber is built into the outlet end of the sedimentation basins for recarbonation at a future date when partial softening with lime may be adopted. Each filter unit is divided into two filter beds which may be operated separately as 2-mgd units or simultaneously as a 4-mgd unit. It is also possible to control 5, 10, or 20 filter units simultaneously by means of a master control system. Filters are provided with both backwash and surface wash. The filter bottoms and underdrain system are of the Wheeler type.

The chemical building houses the chemical storage bins, all chemical feed equipment, the central heating plant, workshop, laboratories, a lecture room, and administration offices. The raw water passes through this building, where chemicals are added, before it enters the reaction or flocculating chambers in the filter building. Dry chemicals are transferred pneumatically directly from the cars into overhead storage bins, whence they pass by gravity to the feeders. At the present time this installation consists of six dry-chemical feeders, two of which feed aluminum sulfate, two lime, and two activated carbon. Orifice-type solution feed equipment has also been installed for experimental treatment with special chemicals. Provision is made for both prechlorination and post-chlorination and ammoniation. Chlorine is fed through vacuum chlorinators from ton containers. Ammonia is fed through displacement-type feeders in aqua form. This is purchased in tank-car lots, stored underground, and pumped to the feeders.

MAIN OPERATING FLOOR IN FILTER BUILDING

Contains Twenty 4-Mgd Filter Units, Ten on Each Side



CENTRIFUGAL LINING MACHINE PLACING $^{1}/_{4}$-IN. CEMENT LINING INSIDE 60-IN. STEEL PIPE

The filtered-water reservoir, some 500 ft from the filter building, is a covered concrete basin 660 by 400 ft in plan, with an effective depth of 18 ft, having a storage capacity of 35 million gal. This reservoir has an auxiliary chamber holding 2 million gal, into which the water first flows before overflowing into the main reservoir. Only the filtered water in excess of that being pumped by the high-service station finds its way into the main reservoir, while the high-service pumps draw from this main reservoir only when the demand exceeds the rate of filtration. This arrangement insures the maintenance of a constant positive head on the high-service pumps and also permits the most economical pumping conditions

with the least practical loss of head between the filters and the storage reservoir.

The high-service pumping station is similar in plan and design to the low-service pumping station. It has, however, three pump pits instead of two, in which are installed a total of five horizontal, bottom-suction centrifugal pumps. The total present installed pumping capacity is 305 mgd. These pumps are driven by 6,900-v synchronous motors, four of the pumps having two motors each, one of 514 rpm and one of 450 rpm, for flexibility of operation. The switch gear and bench board controls are similar to those installed in the low-service pumping station. One overhead and two underground 6,900-v power supply circuits, each from independent sources, serve this station. There is no auxiliary generator equipment at the high-service station.

LAYING 72-IN. HIGH-SERVICE TRUNK MAIN
About Seven Miles of This Type of Main Was Laid in City Streets

The one-million-gallon elevated storage tank is located on the same site as the filter plant and high-service pumping station. This tank is unique in that it serves three functions rather than the usual single one. First, its overflow height of 105 ft above the ground was so fixed to permit its use as a constant-head supply for backwash and surface wash water. Secondly, it serves for surge relief or control in the event of power failure, which would stop operation of all high-service pumping units. In that event, when the pressure in the distribution system drops to a point equal to the hydraulic gradient of the elevated storage tank, water from this tank will immediately be admitted into the distribution system through an automatic check valve to supply the receding cycle of the surge which will develop at that moment. The third function of this tank is to automatically prevent the development of a negative head condition throughout the distribution system during an emergency shutdown at the high-service station.

ELEVATED STORAGE TANK WITH FILTER PLANT IN BACKGROUND

To connect the high-service pumping station with the existing distribution system and to provide the desired improvements in maintenance of water pressures throughout this system, it has been necessary to construct 7 miles of large-diameter high-service trunk mains. These vary in diameter from 72 to 42 in. and are of all-welded steel plate using bolted-ring type couplings for field joints. The 72-in. diameter main, comprising 18,000 lin ft, has a bituminous coating on the outside and a spun bituminous lining on the inside of the pipe. The 60 and 42-in. sections of the trunk main, comprising another 18,000 lin ft, are coated on the outside with bituminous enamel and on the inside with cement lining centrifugally applied following installation.

The 72-in. portion of the high-service trunk main crosses the Maumee River. This crossing, 2,600 ft in length, was constructed in tunnel bored through solid bedrock 120 ft below the ground surface. The same type of pipe (in 20-ft lengths) with similar couplings was laid in this tunnel, the void space between the outside of the pipe and the inside walls of the tunnel being backfilled with concrete. This method avoided all disturbances to the navigation channel during construction, and results in the most secure type of crossing possible.

A LONG PERIOD OF SERVICE EXPECTED

It is contemplated that Toledo's Lake Erie water system as now constructed, assuming normal population and demand increases, will adequately serve the city until 1965 or 1970. When expansion does become necessary, provisions have been made for adding to or expanding certain parts at nominal expense as the need requires. Certain portions, which would be costly to enlarge, were built in excess of the 1970 demand. For example, the intake crib and conduit are estimated to be adequate for anticipated needs until the year 2,000.

A total of $9,884,463 has been expended in the construction of this project, of which the city contributed 55% or $5,436,455, and the Federal Government, through the Public Works Administration, the remaining 45%, or $4,448,008. To obtain maximum competition among the contractors and otherwise to facilitate bidding, the project was divided into 37 separate divisions. This also permitted commencement of construction on some portions of the project while others were still in the design stage. These divisions finally culminated in the award of 29 contracts, some contractors receiving a combination of divisions. Of the total project cost, $8,775,000 was expended on construction contracts, while lands, engineering, interest, and miscellaneous overhead accounted for the remainder.

This project was substantially completed in the summer of 1941. Following an extended period of testing and adjustments, complete operation was started on January 9, 1942. The many expressions of delight in the new water by the citizens of Toledo speak for the satisfactory performance of the project.

Greeley and Hansen, consulting engineers of Chicago, were responsible for the design and for the preparation of plans and specifications. Supervision of construction was handled by the City of Toledo through an engineering organization specially created for the purpose under the Division of Water, with the writer as chief engineer.

Functions of the Civil Engineer Corps in the Naval Establishment

By LEWIS B. COMBS, M. AM. SOC. C.E.

CAPTAIN, (CEC) U.S. NAVY; ASSISTANT CHIEF, BUREAU OF YARDS AND DOCKS, NAVY DEPARTMENT, WASHINGTON, D.C.

OUR Navy deals with the shore as well as with ships; and it is with the organization end of the shore work that Captain Combs is concerned. Delving into our national history he shows how the utilization of civilian engineers as consultants developed naturally into a Civil Engineer Corps as an integral part of the commissioned personnel. How the corps works is his interesting topic. What its constructive activities are in the present emergency was described adequately by Captain Manning in the February number. The two in effect comprise companion papers. The present one is taken largely from Captain Combs address before the Society's Roanoke meeting.

SCANT publicity is given to the Civil Engineer Corps of the Navy. Its whys and wherefores are not too familiar to engineers despite its close relationship with the Society. In other words, the Corps is one of the less colorful but nevertheless very essential parts of the Naval organization.

There always has been a large representation of Society members in the Corps. They now number more than three hundred and fifty. It is unnecessary, therefore, to explain to such a group why a corps of civil engineer officers is necessary to the Navy. Engineers know better than others why officers educated and trained for line duty at sea cannot and should not be expected to assume responsibility for the engineering work of a vast shore establishment, any more than they would be expected to assume the duties of a surgeon or chaplain.

A natural question which is often asked is why the term "civil" should designate a corps in a military organization. This term was originally used to indicate the general type of engineering work handled by the Corps, and the professional qualifications and duties of its commissioned personnel. Today, however, the work involved covers practically all the major engineering branches. We have in the combined regular and reserve Corps many electrical, mechanical, architectural, and some chemical engineers. Quite a few hold master's degrees and law degrees in addition to their basic engineering degrees.

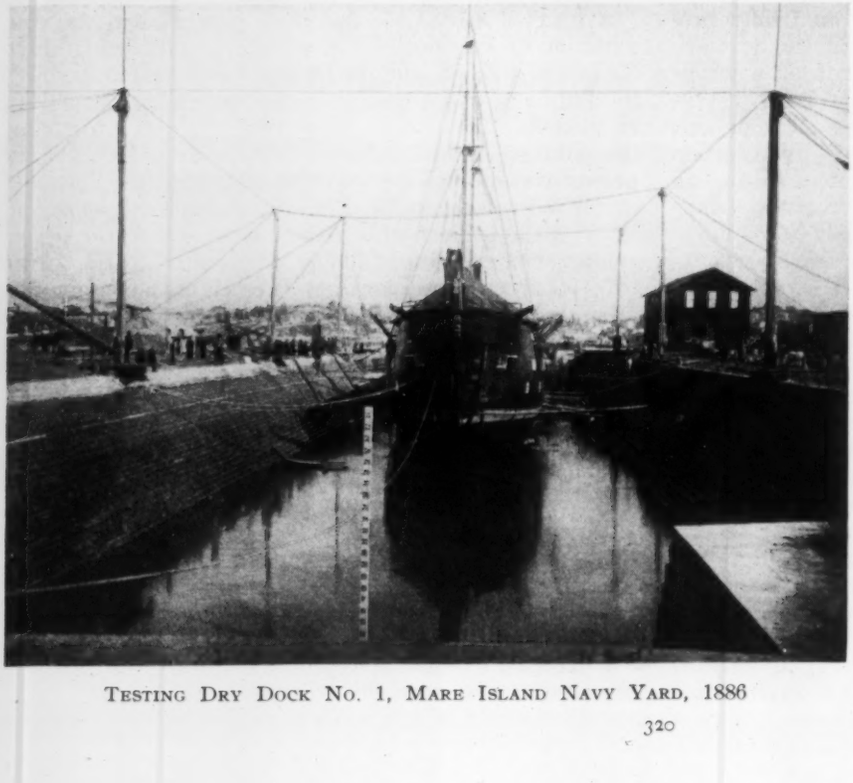
Consideration of a little Naval history will indicate the need for such a Corps of Engineers and its subsequent development. The first legislation toward the creation of a Navy Department was in October 1775. Congress passed a law establishing a "Marine Committee" of three persons chosen by Congress from its own members and gave it control of all Naval matters. Then for a period of fourteen years, or until 1789, the Navy was controlled by various heads under various titles. In 1789, a law was passed placing the Navy under the control of the Secretary of War, and there it remained for nine years.

It must be evident that the administration of Naval affairs had a rather hectic and checkered career during these first 23 years. By an Act of Congress in 1798 a Navy Department was established at the seat of the Government under the control of a Secretary of the Navy. This was the beginning of the present organization.

The first Government Navy Yards were established in 1800 and 1801. Previously Government ships had been built and repaired in private yards or on rented ground. This had proved unsatisfactory and the President directed the Secretary of the Navy to purchase and establish Navy Yards at Portsmouth, N.H.; Boston, Mass.; New York, N.Y.; Philadelphia, Pa.; and Gosport (now Norfolk), Va. These yards still remain at the original locations with the exception of that at Philadelphia, which was moved to League Island in 1868.

In 1807, many years before the Bureau of Yards and Docks was established or the Corps of Civil Engineers thought of, President Jefferson conceived the idea of constructing a huge dry dock capable of accommodating 12 frigates. Benjamin Henry Latrobe was called in as a consultant on this scheme. The dock was never built, but the fact that Latrobe, an eminent civil engineer, was connected with such a Naval shore project indicates that the essential relation between civil engineers and ships was apparent to those early planners and builders. It has since grown continually closer.

In 1815, seventeen years after the establishment of the position of Secretary of the Navy, the Navy Department was supplemented by a Board of Commissioners. This board was composed of captains in the Navy who were appointed by the President and



TESTING DRY DOCK NO. 1, MARE ISLAND NAVY YARD, 1886

confirmed by the Senate. The organization lasted for 27 years, and it was during this period, in 1826, that a consulting engineer was again employed for Naval work.

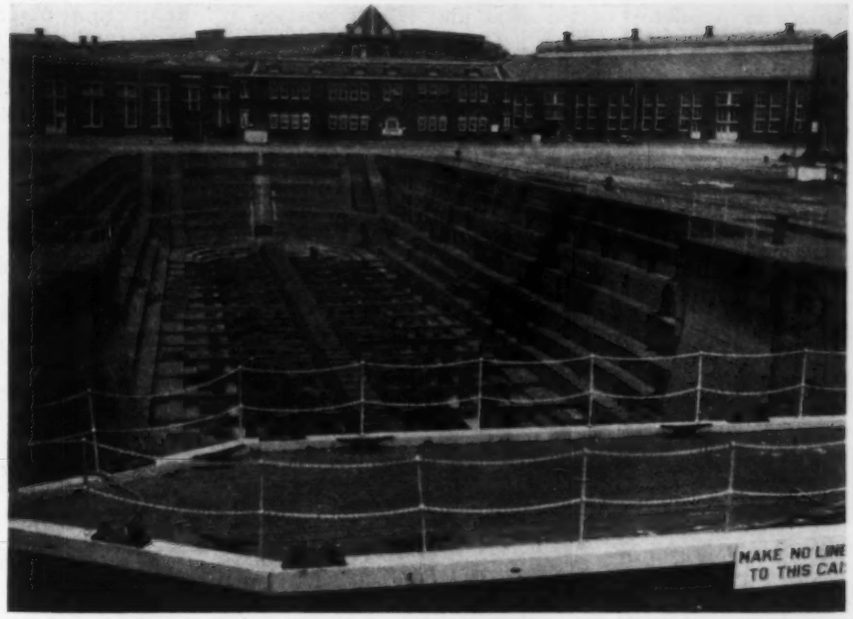
Congress passed a resolution directing the President to cause an examination and accurate survey to be made by a skillful engineer for a site for a dry dock at the Navy Yards—at Portsmouth, Boston, New York, and Gosport. For this work Col. Loammi Baldwin was selected, a well-known canal builder and one of the most prominent civil engineers of his time. He chose for his assistants in the survey and supervision of the construction Capt. A. W. Parris and W. P. S. Sanger, of Boston and Norfolk, respectively, and the granite docks which are still in use at these yards were constructed. Sanger later, in 1867, became the first civil engineer commissioned in the Navy.

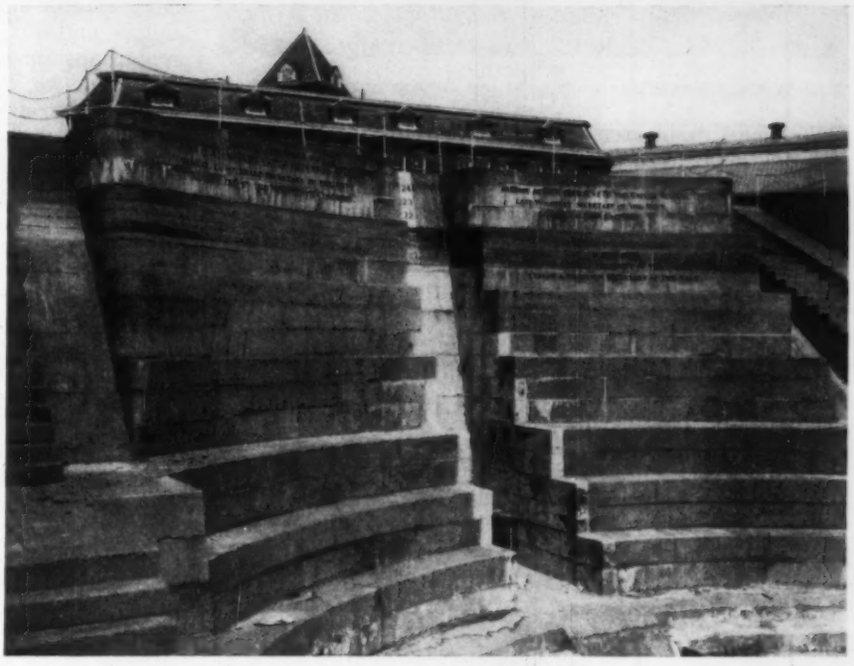
In 1842 Congress passed an Act by which the Board of Commissioners was superseded by a bureau system. There were originally five bureaus. The first one named in the Act was the Bureau of Navy Yards and Docks; it was charged with the design, construction, and maintenance of shore structures. By this time the necessity of employing proficient civil engineers for Naval shore establishment work was clearly seen, and from then on civil engineers in a civilian status were employed at various yards as well as attached to the Bureau of Yards and Docks. In 1858, for their regulation and guidance, a series of rules were drawn up defining the basic duties of the civil engineers of the Navy, very much as they have existed up to recent years.

It was increasingly apparent, however, that engineers employed in a civilian capacity could not provide the necessary mobility and efficiency in a military set-up. Consequently, in 1867, the status of the civil engineers was changed to that of staff naval officers by an Act of Congress which provided that the President might appoint a civil engineer at each of the Navy Yards, such appointment to be confirmed by the Senate. In 1871 another law was passed providing that civil engineers should have such relative rank as the President might fix, and limiting the number to 10. Relative rank was not given to them, however, until February 1881, when their ranks were fixed at one captain, two commanders, three lieutenant commanders, and four lieutenants.

Until 1898 the chiefs of the Bureau of Yards and Docks were officers of the line in the Navy. The first officer of the Civil Engineer Corps to be chief was Rear Admiral Mordecai T. Endicott, who served from April 1898 to January 1907. Admiral Endicott was very active in Society affairs and was elected President of the Society in 1911. Another early engineer commissioned in the Corps who was active in Society matters was P. C. Asserson; he retired in 1901 with the rank of rear admiral. I think all our Chiefs of Bureau have been members of the Society, and the majority of our ranking officers. Many of them have been very active in Society affairs.

An outstanding engineer of his day who was an officer of the Corps, Rear Admiral Robert E. Peary, became a member of the Society in 1886. Each year, on April 6, all CEC officers in the vicinity of Washington gather at his grave in Arlington to hold a ceremony honoring him on the anniversary of his discovery of the North Pole. This year, on the thirty-third anniversary, an interesting thing happened. His daughter, Mrs. Stafford, found among his papers a speech delivered by him before the





NORFOLK NAVY YARD—DRY DOCK NO. 1

Above: General View on One-Hundredth Anniversary, 1933; Inscription Is at Far End. Below: Inscription Viewed from Bottom of Dock; Name of Loammi Baldwin, Engineer, Appears with Those of John Quincy Adams and Andrew Jackson

American Academy of Political and Social Science at Philadelphia in July 1916. She gave it to Admiral Moreell, and he read some of it at the ceremony.

It read like a chart of the future. In it he predicted that the pressure of world events would ultimately compel the federation of all American republics into a single solidarity of defense. He pictured the very fleet of patrol planes which now guards our coast against submarine

BOSTON NAVY YARD—BUILDING CONSTRUCTED IN 1836

and surface raider attack, and declared that our air service of the future would be more vital to our safety than our Navy and Army combined. It was 25 years ago that he uttered those words. With prophetic clairvoyance he foresaw the crisis in which this country now finds itself, and foretold the means by which we could make our victory certain. Peary's final word then is as fresh as though it had been uttered yesterday. "In the coming world influence the one great dominant thing that will overshadow all else will be air superiority and power."

SIZE, GROWTH, AND FUNCTION OF THE CORPS

The Corps has always been relatively small in number, and subsequent to 1916 its authorized strength was legislatively established at 2% of the commissioned officers of the line of the Navy. However, the size was usually governed by budgetary limitations rather than by legislative authority. During the first World War the Corps, augmented by reserve and temporary officers, reached a total of 209 commissioned officers at the signing of the Armistice. This number, compared to its present (April 1942) size of about 1,350 officers, gives an excellent indication of the magnitude of our present effort and the Naval shore establishment construction program involved, as compared with that of 1917 and 1918.

For many years after World War I the Corps was held at less than 100 regular officers. Even today the size is only 150 regular officers on active duty. There was, however, a reserve Corps, and this was the source of a large expansion. It is by the utilization of this reserve that we have been able to accomplish much of what we have. We of the regular Navy look to them with pride and confidence—all are officers of the Civil Engineer Corps and there is no distinction between regular and reserve. We are continuing to recruit actively and probably will go to at least 1,800, perhaps 2,000, reserves.

There are three branches of military science. Strategy is the planning of warfare. Tactics is the execution of strategic plans. Logistics is the supplying of everything necessary to strategy and tactics, in the right amount, at the right place, at the right time. Our job is primarily concerned with logistics.

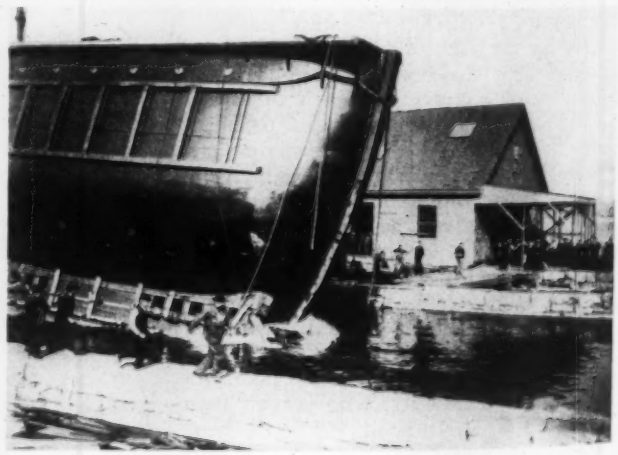
It is the function and responsibility of the Civil Engineer Corps of the Navy, through the medium of the Bureau of Yards and Docks and its field organization, to assist all bureaus and offices of the Navy Department in development planning and to administer directly the design, construction, and maintenance of the shore establishment. Manifestly the Corps is dependent to a great extent upon its civilian assistants and I want to pay tribute to our splendid loyal and efficient civilian organization of technical and clerical personnel in the Bureau and in the field. In every respect they are worthy of the implicit trust and confidence placed in them. In normal times we do our designing with our own Bureau and field organization but there is a feasible limit to the expansion of that organization, and so since 1940 we have utilized the services of private architectural and engineering concerns through the medium of over 250 contracts.

MATERIALS CONSTITUTE MOST SERIOUS BOTTLENECK IN THE WAR EFFORT

Not many years ago it used to be said that the Naval shore establishment was valued at about a half billion dollars, and we felt fortunate if we could get a $10,000,000 annual appropriation for Naval public works. It is too bad that we could not have been spending at least $100,000,000 or more each of those years in an orderly building-up program.

The program of the Bureau of Yards and Docks now on the books, and since June 1940, is approximately $4,700,000,000. Our cash expenditures during April were approximately $130,000,000, but we must get up to a peak of over $200,000,000 per month to accomplish the objective we have set for June 1943.

Of the three possible bottlenecks—namely, labor, materials, and transportation—I believe that materials are going to present the biggest problem. "Speed" is still our primary watchword, and because of the shortage of materials our program is gradually changing in character and type. Up until recently we have built much permanent and semi-permanent work. Now everything is to be the most temporary possible. That is difficult for us in this country because we design well and we build well; we always have; and it is difficult for us to accept the doctrine of skimpy construction. But we have got to do it, and we are doing it. I would like to quote for you a brief statement from a recent directive



LAUNCHING CAISSON FOR A DRY DOCK AT BOSTON NAVY YARD

issued by the Secretary of the Navy to all shore activities, "Projects Essential for the War Effort."

"In this war effort there is no such thing as a non-critical material. Experience has shown that what is non-critical today will be critical tomorrow. Therefore, we can consider that all materials are critical, some being more critical than others. Under this premise no building project, large or small, should be undertaken unless it can be shown to be essential to the war effort. Even then, once a building is decided upon, it should be of the cheapest temporary character consistent with the use to be made of it and utilizing those materials which are most plentiful. All materials are very scarce. In many instances the scope and character of construction is influenced by considerations of post-war needs. All construction must be limited to what is immediately necessary to win the war. Post-war needs are unpredictable. What we now think will be very useful may turn out to be of little or no utility. The unnecessary use of any building materials will inevitably react to interfere with the Navy's overall program as well as with the program of other war agencies."

I have been asked frequently, "How can the civil engineers of the Society and of the country best help? What can they do to best fit in this all-out war effort?" I don't know of any panacea. I don't think there is any general answer. Each must go out and seek his own best place and then perform the task, regardless of how small it may seem, with the full devotion, loyalty, and strength which are within him. War is a great dislocator of normal pursuits and producer of inequities. We are only just beginning to feel it. I think if the engineer can help make the country realize the situation, and particularly the material situation, the critical shortages, he will contribute much.

ORGANIZATION OF THE "SEABEES"

Until recently our work beyond the continental boundaries has been accomplished by civilian personnel under contract, but it becomes increasingly evident that such work, and particularly that at advanced and mobile fleet bases in combat zones, must be done by military personnel. We are therefore now recruiting and training new units known as Naval Construction Battalions. Men are being enlisted in the various Naval ratings which most nearly conform to the trades required for construction. Each battalion is made up of four construction companies and one headquarters company totaling 1,073 men. Three battalions will comprise one construction regiment but they will undoubtedly be used as smaller units.

Commenting on this special recruiting drive, Rear Admiral Ben Moreell, M. Am. Soc. C.E., Chief of the Civil Engineers of the Navy, and Chief of the Bureau of Yards and Docks, said, "This is a real opportunity for those two-fisted, red-blooded Americans who are not fighting behind a gun to serve shoulder to shoulder with the combatant forces of the Naval service." But one thing they will be taught in their relatively short course of military training is how to handle a gun in case it is necessary—and it may well be.

The result of our recruiting campaign has far exceeded our expectations; in fact, the Recruiting Offices have been fairly deluged with applications. By the end of May we expect to have recruited six regiments, approximately 20,000 men, and we have just received authority from the Secretary to increase this to twelve regiments, or a total of 40,000 men. The officering of these twelve regiments will require about 600 Civil Engineer Corps officers. Construction regiments have been given official sanction for the nickname of "Seabees"—phonetic of the abbreviation C.B., for Construction Battalion.

During the last war we had a somewhat similar organization known as the "Public Works Regiment" at the Naval Training Station, Great Lakes. It was originated primarily for the construction and maintenance of the training station and not to be sent away. It finally developed into one of the principal training regiments of the station for seagoing men because of the many skilled trades involved.

TYPE OF PERMANENT CONSTRUCTION—AMMUNITION DEPOT, IONA ISLAND, N.Y.

Naval warfare, however, will now be prosecuted in a very different manner from what it was in 1917 and 1918, and bases, particularly those that can be constructed quickly—we call them "mobile bases"—will form a very important part of the Naval effort. Consequently, it is essential to have units that can build them in our Naval organization. These construction units will be under the command of officers of the Civil Engineer Corps—a new function for the Corps.

There is a task before the American people the magnitude of which neither you nor I can fully grasp, nor do I believe that its limits have yet been disclosed. It is not a question of what we would like to do about it. We are opposed by two aggressive enemies on two fronts, each bent on definite conquest. Success for either will be a stepping stone for further aggression and eventual economic, if not political, subjugation. Both must be, and will be, defeated. With all the breaks that will now be a tremendous task; and without the breaks, and that is the only way we dare to figure it, it is evident that this country has embarked on a stupendous effort which will require every resource that we can bring to bear, and the individual efforts of every man and woman. There is a tendency to place too much public emphasis on the few successes and too little on the many reverses. I do not think that the real American spirit is yet awake in the majority of the people of this country, especially those, of whom there are millions, who so far have had no direct contact with the war effort.

We have battles to win on three fronts against both enemies and each is equally important:

Battle of production
Battle of transportation
Battle of combat

Our fundamental philosophy is "No one can drive us," but "We must drive ourselves." May God give every one of us the strength to do it now to our fullest capacity.

Development of the Science of River Measurement Hydrology

By JOHN C. HOYT, M. AM. SOC. C.E.
CONSULTING HYDRAULIC ENGINEER, U.S. GEOLOGICAL SURVEY, WASHINGTON, D.C.

THE science of hydrology, of which river measurement is an important part, deals with the factors that determine the behavior of water from the time it falls on the earth as rain or snow until it returns to the atmosphere or disappears as ground water. In practice, this science is generally applied to the surface and ground waters that are available for various human activities, and to the meteorological and other conditions that affect their occurrence and distribution.

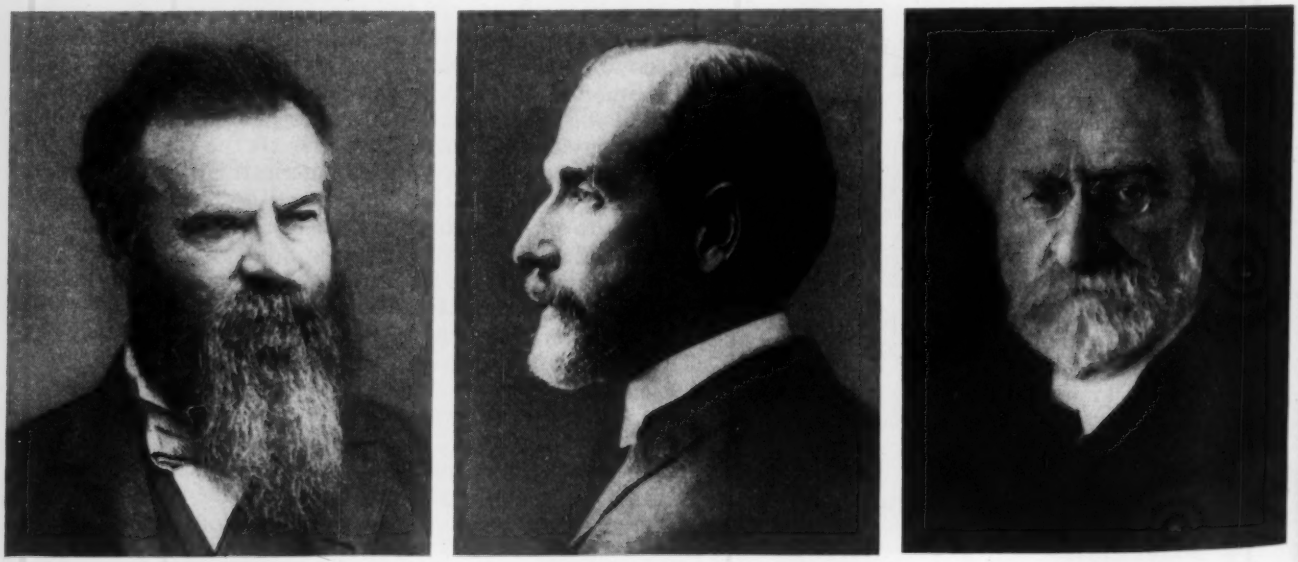
At all times and in all localities the character and extent of man's activities have depended on the available water supplies. Other resources and conditions in an area will, in part, determine the character of the development, but the extent of the development is primarily dependent upon the available water.

EARLY EGYPTIAN GAGE FOR RIVER MEASUREMENT

In this country early settlement took place largely in the humid areas, in general along river courses where there was adequate water to satisfy domestic needs. The principal other early uses of water were for navigation and small water power installations. Therefore there was little need to consider water-supply problems. As the country advanced there has not only been an increased demand for water in the humid areas but activities requiring water have been extended to the arid and semi-arid areas. Thus the earlier limited requirements, which were mainly for domestic use, have been expanded into industrial use, recreational use, navigation, irrigation, and hydroelectric power. Today virtually every locality has its water problems, and as a result, a general water-mindedness has developed throughout the country. Everywhere there is general interest in some phase of the water problem, either from the standpoint of its availability for various essential uses, or because of the damage that results from excessive flood flows or from drought. This interest during recent years has resulted in a rapid advancement in the science of hydrology. Its importance is now recognized as essential in planning all developments depending on water.

That there was at least an appreciation of hydraulics at an early date is evident from the extensive ruins of water supply, irrigation, and other works. Archimedes (c. 287–212 B.C.) and other Greek philosophers were much interested in the pursuit of science for its own sake, as a form of recreation. They had little or no interest, however, in the practical application of scientific principles. They recognized some of the fundamental theoretical principles of hydraulics but were not interested in applying them for man's use.

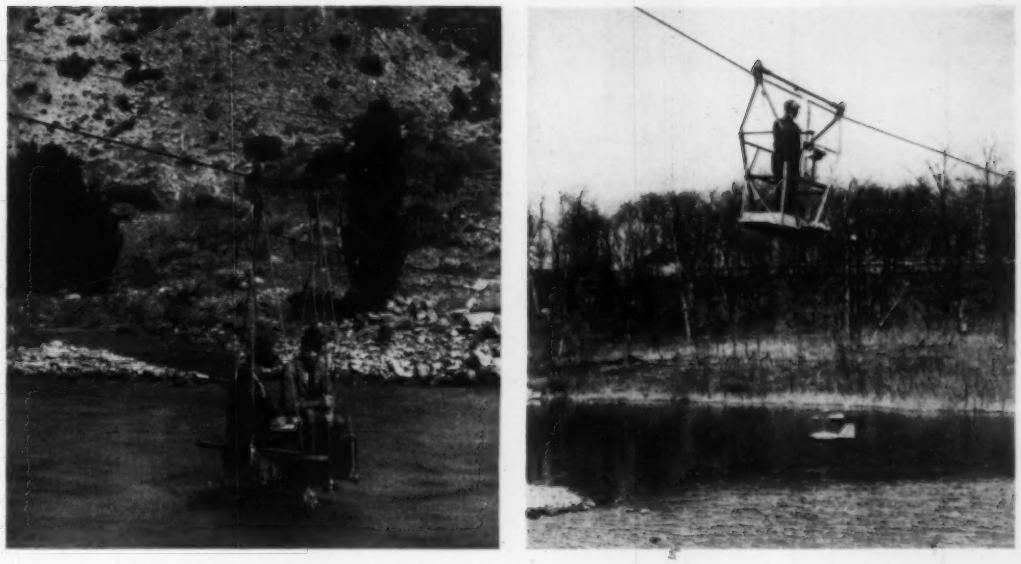
The first historical personage to apply scientific principles for the use and benefit of his fellow men, and to leave a written record of it, was Heron of Alexandria, who lived in the second century B.C. He was an eminent



PIONEERS IN HYDROLOGY
Left, Maj. John Wesley Powell; Center, Dr. Frederick H. Newell; Right, Past-President Clemens Herschel

mathematician and philosopher and had an understanding of facts and principles with which the ancients have seldom been credited. His principal interest in science was in its practical application, and he invented and constructed numerous machines and mechanical devices which later served as prototypes and led to many practical inventions.

He was the author of many books. Fourteen of these were translated by Pappus in the third century A.D., who also mentions five others which were lost. His best-known book was *Pneumatica* which described many of his own inventions, including the first steam engine. Another especially interesting to engineers is *Dioptera*, in which the principles of land surveying and leveling were first made known. For these reasons Heron has been called the first engineer.[1]



MEASURING RIVER FLOW BY CABLE CAR—LEFT 1890, RIGHT 1942

In his *Dioptera*, Chapter 31, Heron enunciates the following hydraulic principle:

"Observe always that it does not suffice to determine the section of flow, to know the quantity of water furnished by the spring. This we said was twelve square digits. It is necessary to find the velocity of its current, because the more rapid the flow, the more water the spring will furnish, and the slower it is, the less it will produce. For this reason, after having dug a reservoir under the stream, examine by means of a sun-dial how much water flows into it in an hour, and from that deduce the quantity of water furnished in a day." This statement shows a clearer understanding and better practice than appear two hundred years later in Roman writings on the subject, when the City of Rome was supplied with water by nine aqueducts with a total length of 250 miles and discharging 27,000,000 cu ft per day.

In the year A.D. 97 Sextus Julius Frontinus, then superintendent of Rome's water supply, wrote a description of this system under the title *De Aquis*,[2] which gives an account of its construction and operation. No doubt, Frontinus had the benefit of Heron's teachings and writings. However, he had only a hazy idea of velocities of running water and none at all of cubic feet per second or any equivalent of such a term, and he failed to appreciate the time element.

The progress of science moved very deliberately at that time in the world's history, and there was little further development in hydrology until the era of Leonardo de Vinci (1452–1519 A.D.). As is well known, Leonardo was not only the creator of the Mona Lisa, The Last Supper, and other works of art, he was also one of the world's greatest scientists and engineers. His understanding of hydraulic laws is indicated by the reasons he gave to account for variations in the discharge from a canal through an orifice:

"1. By reason of the height, more or less great, that the surface of the water of the canal is over the opening.

"2. By reason of the more or less velocity with which the water of the canal passes along the bank in which is placed the opening.

"3. By reason of the sides of the opening being more or less convergent.

"4. By reason of the thickness of the frame of the orifice being greater or less.

"5. By reason of the shape of the opening being circular, or square, or triangular, or lengthened out.

"6. By reason of the axis of the opening being more or less inclined to the direction of the bank of the canal.

"7. By reason of its being more or less inclined to the horizon.

"8. By reason of the opening being placed on a convex bank or on a concave one.

"9. By reason of the protuberances or depressions in the bed of the canal, opposite to the opening.

"10. By reason of the air intermingling or not intermingling with the current of water that discharges from the opening.

"11. By reason of the water discharging from the opening freely into the air, or discharging through an open conduit, or through a closed pipe.

"12. By reason of this conduit having a cross-section greater or less than the orifice of discharge.

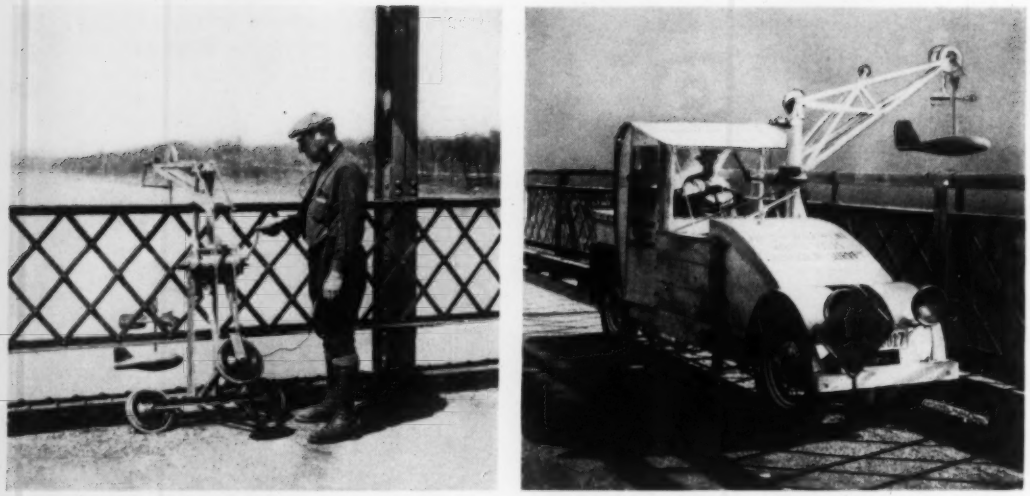
"13. According as this conduit is of greater or less length.

"14. According as the interior of the conduit is smooth or rough, straight or curved."

These points cover the essential phases of the problem, and but little has been added to them since.

It was not until the seventeenth century, under the influence of Galileo (1564–1642), and mainly through his two pupils, Castilli (1577–1644) and Torricelli (1608–1647), that the science of hydrology began again to progress. A marked advance was made by the introduction of quantitative measurements, which resulted from the studies[3] of Pierre Perrault (1628–1703), Edme Mariotte (1620–1684), and other French physicists, and by the English astronomer Edmund Halley (1656–1742).

Perrault made measurements to compare rainfall and runoff from a portion of the Seine River basin. Mariotte extended these measurements to cover the entire basin of the Seine above Paris, and credit for originating the science of ground-water hydrology should probably go more to him than to any other man—in fact, the further development of the whole science of hydrology was largely due to his work. It is difficult to determine the relative credit that should be given to Perrault and to



MEASURING RIVER FLOW FROM A BRIDGE
Left, with Hand Boom and Reel; Right, with Power Boom and Reel

Mariotte; however, Perrault was evidently the first to make quantitative studies of rainfall and runoff. Halley's principal work related to evaporation and demonstrated that the moisture evaporated from the ocean was sufficient to supply all the water in springs and streams.

The writings of Pitot (1730), Daniel Bernouilli (1738), M. Dubuat (1786), and M. DeProny (1804) were notable contributions to the science of hydrology. The modern school of hydraulics dates from 1764, when Professor Miscelloti of Turin published the results of his studies and experiments and established the fundamental principle that hydraulic formulas must be deduced from experiment and not from abstract reasoning.

CHEZY FORMULA DEVELOPED

In 1775, M. Chezy, the celebrated French engineer, developed the formula known by his name, $V = c\sqrt{Rs}$. This, the first algebraic expression of the law of moving water, has served as the basis for all subsequent slope formulas. In 1869 W. R. Kutter[4] developed a formula, known by his name, for determining the coefficient c, to be used with the Chezy formula.

Current meters for measuring the surface velocity of flowing water in streams were devised in the latter part of the eighteenth century by Borda and Dupuit. About 1790 Woltmann devised a wheel which could be used for measurements below the surface. This was later fitted with a recording device by Le Point.

Although many others contributed, the early development of the science of hydrology was largely due to those mentioned. Their writings on hydraulic subjects, however, are now of but little practical importance in engineering practice.

Interest in hydrology started in the United States between 1840 and 1850, when Humphreys and Abbott[5] started their investigations of the Mississippi River and its tributaries. About the same time Charles Ellet used a rating curve based on measurements of discharge to determine the daily discharge of the Ohio River at Wheeling.[6] The first extended series of measurements of river discharge in the United States, in which the current meter was used for determining velocities, was made on the Connecticut River by Gen. Theo G. Ellis in connection with studies begun in 1871.[7] The venturi meter for measuring water in closed conduits was developed in 1887 by Clemens Herschel.[8]

Systematic hydrologic studies in the United States were started in 1888 to supply information on water supplies in connection with the investigation of irrigation possibilities in the arid states by the U.S. Geological Survey.[9] The idea originated with John W. Powell, the second director of the Survey, who, with Capt. C. E. Dutton, outlined the plan of procedure. The development of the plan and the working out of details were under the direction of Frederick H. Newell, a leading force in the work, who more than anyone else was responsible for its success.

At the start there were no established methods or instruments for conducting the investigation, and to develop them a camp was organized on the Rio Grande at Embudo, N.Mex., under Mr. Newell's direction. A river-measurement station was established and the first measurement of discharge made December 21, 1888, by J. B. Williams. This date can be taken as the beginning of the systematic collection of hydrologic data in the United States. From this beginning the work has been expanded. Instruments and equipment have been developed and methods of collecting various data determined, until now practically every phase of hydrology is covered.

Although many have contributed to the development of the science of hydrology, its present status has resulted largely from the lead given by the engineers of the U.S. Geological Survey, especially through its stream measurement work, which has been systematically carried on for over fifty years and yields the principal basic data for all hydraulic studies. Records of flow are now available for over 8,500 points on streams in the United States and are now being kept at over 4,000 points.

The results of the Survey's hydraulic studies are published in a series of over 900 Water-Supply Papers, which contain records of the measurements of stream flow and of various other hydraulic studies. They have served as a basis in the design, construction, and operation of various projects which depend on water for their successful operation. The records of available water supplies collected by the Survey have also been of great value in connection with the location of various war activities, such as cantonments, air fields, munition and war industry plants, which require adequate water supplies for their successful operation.

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The Civil Engineer and the Wage and Hour Law

By L. METCALFE WALLING

ADMINISTRATOR OF THE FAIR LABOR STANDARDS ACT AND THE WALSH-HEALEY PUBLIC CONTRACTS ACT, NEW YORK, N.Y.

MUCH important legislation of special interest to the civil engineer has been enacted in Washington during the past few years. To keep our readers up to date, it is planned to run from time to time a number of special articles or reviews dealing with these laws. Of particular interest are the statutes concerned with employee-employer relationships, such as the "Fair Labor Standards Act of 1938," commonly called the "Wage and Hour Law," the "National Labor Relations Act," commonly called the "Wagner Act," the rules and regulations of the National Labor Relations Board, and others. In the June 1941 issue of "Civil Engineering" General Philip B. Fleming, former Administrator, outlined the Wage and Hour Law. This article by his successor brings the subject up to date.

THE basic provisions of the Fair Labor Standards Act are simple. They merely require, first, that a wage of not less than 30 cents an hour be paid to all employees (unless specifically exempted by the Act) engaged in interstate commerce or in the production of goods for interstate commerce. In some industries a higher minimum wage has been set, although in no case is the minimum under this law above 40 cents. They require, second, that such employees be paid not less than time and a half their regular rate of pay for all hours worked over 40 in any single work week. Third, employers subject to any provision of the Act must keep certain records as to the hours of work and rates of pay of employees.

These are the three provisions most directly affecting engineers and employees of engineering firms. Interpretative bulletins and regulations, issued under the Act by the Division, discuss them in detail. Exemptions authorized under the Act for professional engineers and others also are discussed in publications of the Division. Complete information as to the requirements of the law and the interpretations of the Division have been broadcast freely, yet violations still occur.

VIOLATIONS NOT WILFUL

Fortunately, among civil engineers as a whole, a spirit of mutual cooperation exists which greatly simplifies employer-employee relationships. Among engineering firms, however, there have been cases of violation of this law—although it must be added the violations generally were not wilful. When called to the attention of the executives in each concern the violations were quickly corrected. In three specific cases, sums representing the differences between the wages actually paid and the wages that should have been paid under the Act, amounting to $20,000, $40,000, and $50,000, were paid to employees.

The law instructs the courts to assess fines up to $10,000 for wilful first offenses; and imprisonment for six months with or without a $10,000 fine may be imposed for second offenses. Violations of the Act may be enjoined, as may the shipment in commerce of goods produced in violation of the Act. Had any employees of the violating firms just mentioned been so disposed, they could have brought suit for the amount of back wages due them, as the Act makes mandatory an award of double the amount due in successful employee suits. It further requires that plaintiff's attorney fees and court costs be assessed against the defendant. By making restitution to their employees these firms probably saved themselves possible litigation and double liability under employee suits which might otherwise have been brought.

Represented among the violating firms in the records are consulting engineers, construction engineers, oil and mining men, topographical and highway engineers, structural, electrical, and mechanical experts, geological survey services, marine and management engineers, and virtually every remaining branch of the profession.

Most of the violations in the engineering profession have been of Section 7 of the Act, which comprises the overtime provision; and of Section 11 (*c*), which is the Administrator's authority for the requirement of employment records applying to the establishments covered. Only occasionally have we found infractions of Section 6 of the law dealing with minimum wages. These occurred primarily during the earlier days of the Act. Sometimes they are found in plants operating under industry wage orders establishing wage minima higher than the statutory 30-cent base.

Congress in writing the law planned that the national minimum wage in all covered industries would be 40 cents an hour by October 1945. The Administrator is directed by Congress to appoint special industry committees to investigate economic and other conditions in industries believed to be in a position to absorb the increased wage rate prior to 1945. Following recommendations of these committees, special wage orders have been issued in about 30 industries. Committees have been appointed altogether for 38 industries, employing approximately 7,325,950 workers, of whom it is estimated that 1,727,977 have actually had or will have their wages increased.

OVERTIME PAYMENTS

The overtime regulations are not difficult to understand. The whole thing boils down to "time and a half for work beyond 40 hours." There is no requirement for double time, for night work, or for Sunday or holiday work. If it were feasible for 40 hours to be worked all in one stretch, there would be no violation as far as the Wage and Hour Law is concerned, provided that overtime were paid for work beyond that limit, since there is no daily overtime rate.

Nowadays, however, engineering employers working on Government contracts of certain types, should remember that the Walsh-Healey Public Contracts Act requires payment for overtime beyond 8 hours in any one day or 40 hours a week. In other words, under the Fair Labor Standards Act an employee need not be paid overtime until the first hour after his full 40, but employees on certain Government contracts are entitled to

overtime for every hour beyond 8 in any consecutive 24 hours.

The Walsh-Healey Act prescribes labor standards in the execution of any contracts made by the United States "for the manufacture or furnishing of materials, supplies, or equipment in any amount exceeding $10,000." Draftsmen engaged in the preparation of drawings which are required to be supplied to the Government, or which are prepared subsequent to the date of contract for use by the manufacturer in producing the materials and equipment for the Government, are held covered by the Walsh-Healey requirements of time and a half after 8 hours. The Walsh-Healey law does not apply, however, to supervisory draftsmen or in general to other supervisors.

PROFESSIONAL ENGINEERS EXEMPT

Professional engineers actually engaged in their professions are exempt from the overtime provisions of the Wage and Hour Law provided that they are paid at least $200 a month in salary or fees and that their duties are fully in line with the requirements outlined by the Administrator in Title 29, Chapter V, Code of Federal Regulations, Part 541. Copies of the regulations, which also define the requirements for exemption of executive and administrative workers, may be obtained from any branch office of the Division, or direct from the national office at 165 West 46th Street, New York, N.Y.

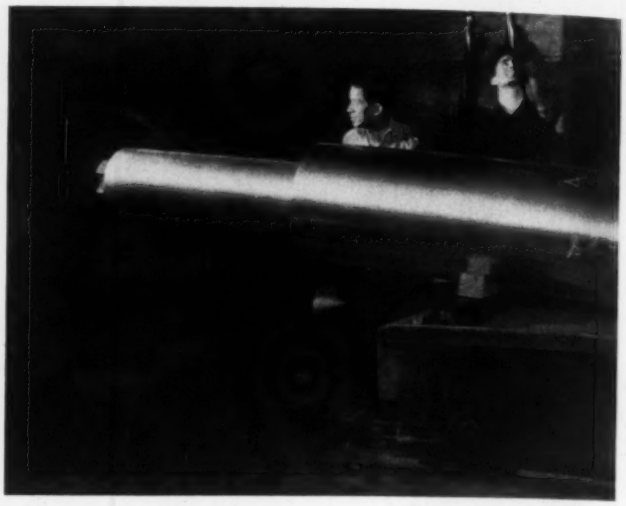
Many of the Wage-Hour overtime violations have occurred through misunderstanding of this section, and we have found that the professional exemption has even been claimed for everyday draftsmen. Some supervisory draftsmen may be exempt from the Wage-Hour overtime requirements as administrative employees if they are drawing $200 or more a month in salary or fees. But here again, care must be taken that they are employed in line with the Part 541 definition.

In the construction field, some employees may not be covered by the law. This would occur when they are engaged solely in what may be termed "original construction" of buildings. In some phases of original construction—such as the construction of highways and other instrumentalities of interstate commerce—the Division has taken no position as to whether the Act is applicable to the construction workers. This means that the Division is not presently enforcing the Act in cases where the sole possible basis of coverage on an employee stems from the fact that he is engaged in such original construction. However, employers are cautioned that the Division considers the problem a close one, and that the courts in cases brought by an employee under the Act may well hold such work to be covered.

If an employee, for any part of a work week, is engaged in the maintenance, repair, or reconstruction of an essential instrument of interstate commerce or of buildings or machinery used to produce goods for interstate commerce, he is covered by the Act for all hours worked in that week. The line between original construction and reconstruction is often difficult to draw. Of course, when an engineering firm engages in interstate operations within its own organization—such as constructing buildings in states other than that in which the central office is located—employees in the central office, such as draftsmen preparing plans to be sent across state lines, and other office employees, are covered by the Act.

Some overtime violations have occurred when a weekly salaried employee has been paid for overtime at an arbitrary rate rather than at time and one half his "regular rate of pay." The regular rate of pay of a salaried employee is normally determined in any work week by dividing his weekly salary by the number of hours worked in the particular week in question.

Care should be exercised by employers subject to the Act in the maintenance of adequate records for Wage-Hour purposes. The required information normally will be available under any standard system of bookkeeping, but the regulations should be consulted in order that an employer may be assured that his records are adequate and accurate. Failure to keep adequate records in itself is a serious violation. Interestingly enough, our inspectors long ago found that satisfactory records can often be accepted as prima facie evidence of satisfactory compliance.



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SKILLED WORKERS HANDLING A HUGE ELEMENT FOR A ROLLING MILL

Typical of the Many Non-Engineers Most Affected by the Wage and Hour Law

EFFECT ON WAR PRODUCTION

In view of the criticism which recently was aimed at the 40-hour week, there are one or two final thoughts. Probably no one knows better than the readers of CIVIL ENGINEERING that there is no such thing as a 40-hour week, as such, in the nation today. Official and non-official figures on hours of work printed in the daily press show that we are rapidly approaching the goal of 160 and 168 hours operation in vital defense plants. Only a scant handful of employers actually engaged in war production have complained that the so-called 40-hour law is impeding our program of total production for total war. The chief complainers have been those who opposed the Act from the start—employers and others who would like to see the return of the sweatshop type of employment which the Fair Labor Standards Act was designed to abolish.

Some critics, fired as we all are by the overpowering necessity to win the war, have honestly thought that the Wage and Hour Law's overtime requirements stood in the way of the goal. But as these sincere doubters have learned the facts, the ranks of the opponents have been considerably diminished.

I am confident that the law's regularization of labor standards, which are both uniform and fair, is making a real contribution to smoother and greater production—and thus to winning the war. And I compliment the engineering profession as a whole on its cooperation with the Government in the enforcement of these laws.

Engineers' Notebook

Ingenious Suggestions and Practical Data Useful in the Solution of a Variety of Engineering Problems

The Importance of Considering Side-Wall Friction in Bed-Load Investigations

By JOE W. JOHNSON, ASSOC. AM. SOC. C.E.

HYDRAULIC ENGINEER, SEDIMENTATION DIVISION, SOIL CONSERVATION SERVICE, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

IN the ordinary flume used for bed-load studies, the roughness factor for the smooth side walls usually is much smaller than that for the granular bed. Consequently, frictional forces are not uniformly distributed over the cross section, and computations based on certain assumptions are necessary to determine that portion of the tractive force acting only on the bed. Bed-load formulas based on data in which the influence of the side walls has been eliminated give results for channels of infinite width and are more generally applicable to bed-load problems. Failure to eliminate the influence of the side walls in certain studies may cause the importance of other factors to be erroneously estimated. The particular importance of the studies here summarized is that they include the effects of temperature and viscosity.

The general principles involved in determining the distribution of friction over a cross section with varying roughness have been outlined by H. A. Einstein, Assoc. M. Am. Soc. C.E. ("Formulas for the Transportation of Bed Load," March 1941 PROCEEDINGS, p. 351). The basic concept of this method is that the entire cross-sectional area can be divided into subareas that will correspond to certain sublengths of the wetted perimeter, and that the potential energy of a certain subarea is transformed into eddy energy along the corresponding sublength of the wetted perimeter, the eddies being accelerated and destroyed again in the same subarea. In a simple cross section the average velocity and the slope are assumed to be the same in all subareas, and friction formulas can be applied simultaneously to describe the flow in the various subareas. Let the areas, hydraulic radii, and roughness of the component areas be as indicated, respectively, by the A, R, and k values in Fig. 1. Then

$$\text{Total area} = A = A_w + A_w' + A_b \quad \ldots\ldots(1)$$

$$\text{Wetted perimeter} = P = 2d + B \quad \ldots\ldots(2)$$

and

$$R_w = \frac{A_w}{d};\quad R'_w = \frac{A'_w}{d};\quad R_b = \frac{A_b}{B} \quad \ldots\ldots(3)$$

The velocity, V, in each subarea is assumed to be a function of the average velocity in the cross section, and of the hydraulic radius, the slope S, and the roughness k; that is,

$$V = \frac{Q}{A} = f_1(R_w, S, k_w) = f_2(R'_w, S, k'_w) = f_3(R_b, S, k_b) \quad \ldots\ldots(4)$$

where Q is the discharge in the entire section. Any of the established friction formulas may be used in Eq. 4. For example, the Manning formula may be used entirely, or as illustrated below, the formula for flow in smooth pipes may be used for flow along the side walls and the Manning formula used only for the bed.

In the ordinary bed-load investigation, the tractive force on the bed and the bed roughness are used in the analysis of the data. The numerical values of these terms may be computed from the given equations in several steps, as follows: Compute the hydraulic radius of the side walls by a suitable friction formula from known values of V, S, and k; multiply the hydraulic radius of the wall by the corresponding wetted perimeter to obtain the subarea of the wall; the subareas of the two walls added together and subtracted from the total area of the section give the subarea of the bed, which, when divided by the flume width (wetted perimeter of the bed), gives the hydraulic radius of the bed. With the hydraulic radius of the bed now known, the tractive force on the bed may be computed directly from the tractive force formula, and the bed roughness may be computed from a suitable friction formula.

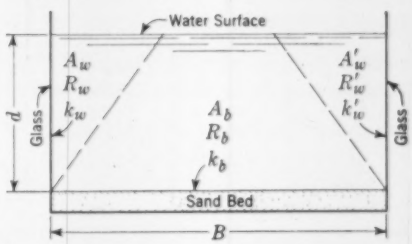


FIG. 1. DIVISION OF FLUME CROSS SECTION INTO AREA UNITS, WITH NOTATION

VISCOSITY EFFECTS

The Manning friction formula gives results that are satisfactory for most bed-load investigations. In some instances, however, viscosity effects resulting from temperature variations are appreciable, and the Manning formula alone is not adequate. In such cases a friction formula, with a factor for viscosity, must be used for that part of the flow where viscosity forces are appreciable, that is, for flow in contact with the side walls. A formula of this type is von Kármán's law for flow in smooth pipes (Eq. 7).

Consider, as an example, the flume with sand bed and glass side walls shown in Fig. 1. If the two side walls have equal roughness, the entire cross section can be considered to consist of two units—the bed and side walls. Side-wall friction may be expressed by the shear at the wall as in turbulent flow in smooth pipes, that is,

$$\sqrt{\frac{\tau_0}{\rho}} = V\sqrt{\frac{f}{8}} \quad \ldots\ldots(5)$$

where τ_0 = intensity of shear at the pipe wall, i.e., side-wall friction
ρ = density of fluid, or mass per unit of volume
V = average velocity of flow for the entire cross section
g = gravitational acceleration
f = coefficient of pipe resistance

With side walls of equal roughness, R_w equals R_w', and the wall shear is

$$\tau_w = R_w \rho g S = R_w' \rho g S$$

For flow along the flume side walls, Eq. 5 may then be written

$$\sqrt{R_w g S} = \sqrt{R_w' g S} = V\sqrt{\frac{f}{8}} \quad \ldots\ldots (6)$$

The following relationship between the resistance coefficient f, and a universal constant and Reynolds number **R**, has been developed for smooth pipes by von Kármán (*Fluid Mechanics for Hydraulic Engineers*, by Hunter Rouse, page 248):

$$\frac{1}{\sqrt{f}} = -0.8 + 2 \log (\mathbf{R}\sqrt{f}) \quad \ldots\ldots (7)$$

in which case the Reynolds number is:

$$\mathbf{R} = \frac{\text{mean velocity} \times \text{pipe radius}}{\text{kinematic viscosity}}$$

but, since the value of the pipe radius is twice the hydraulic radius of the pipe, the Reynolds number also can be written

$$\mathbf{R} = \frac{2VR}{\nu} \quad \ldots\ldots (8)$$

where V = mean velocity, R = hydraulic radius, and ν = kinematic viscosity.

The hydraulic radius of the side walls in a flume can be found from Eq. 6 by first determining the proper value of f from Eq. 7. This procedure involves a trial-and-error calculation in which a value for the hydraulic radius of the wall, R_w, first is assumed, and the value of the Reynolds number is then computed by Eq. 8. The value of f is next computed from Eq. 7 or more simply, by using a curve of f versus **R** plotted from Eq. 7. The values of f corresponding to the calculated value of the Reynolds number is next inserted in Eq. 6 with known values of S, g, and V, and the value of R_w is computed. If the calculated value of R_w differs appreciably from the original assumed value, another value is assumed and the procedure is repeated. Usually only two or three trials are required to give a value of sufficient accuracy for most studies.

With R_w for one side wall being known, the subarea of flow along each wall is

$$A_w = dR_w \quad \ldots\ldots (9)$$

the subarea with reference to the bed is

$$A_b = dB - 2(dR_w) \quad \ldots\ldots (10)$$

and the corresponding hydraulic radius of the bed is

$$R_b = \frac{A_b}{B} = d\left(1 - 2\frac{R_w}{B}\right) \quad \ldots\ldots (11)$$

The tractive force on the bed, therefore is

$$\tau_b = \gamma R_b S \quad \ldots\ldots (12)$$

where $\gamma = \rho g$ = weight per unit of volume.

Also of interest in some experiments is the discharge per unit width of the bed, that is

$$q_b = VR_b \quad \ldots\ldots (13)$$

APPLIED TO TEST DATA

The importance of eliminating the effect of side-wall friction, and thereby permitting the results of bed-load experiments to be summarized on the basis of channels of infinite width, is well illustrated by Ho Pang-Yung's experiments, which were designed to evaluate the effect of temperature on the rate of bed-load transportation (Abhängigkeit der Geschiebebewegung von der Kornform und der Temperatur, Mitteilungen der Preussichen Versuchsanstalt für Wasser, Erd-, und Schiffbau, Berlin, No. 37, 1939). These experiments were conducted in a glass-wall flume approximately 16 in. wide, 22 in. deep, and 52.5 ft long. A well-rounded sand with an average diameter of 1.4 mm was tested at a slope of 1:100 with various water temperatures. During each experiment, in which the water-surface slope was maintained parallel to the bed by adjusting the tailgate, measurements were made to determine the discharge, depth, water temperature, and rate of bed-load transportation.

Data from these experiments are shown in Fig. 2 (*a*), wherein the rate of bed-load transportation at various water temperatures is plotted against γdS, the usual form of tractive force. This method of plotting, which assumes that all friction is concentrated on the bottom, would indicate that temperature has a decided effect on the rate of bed-load transportation. The conclusion may be misleading, however, since the friction along the side walls is not considered in the expression γdS. If the side-wall friction is appreciable, this expression for

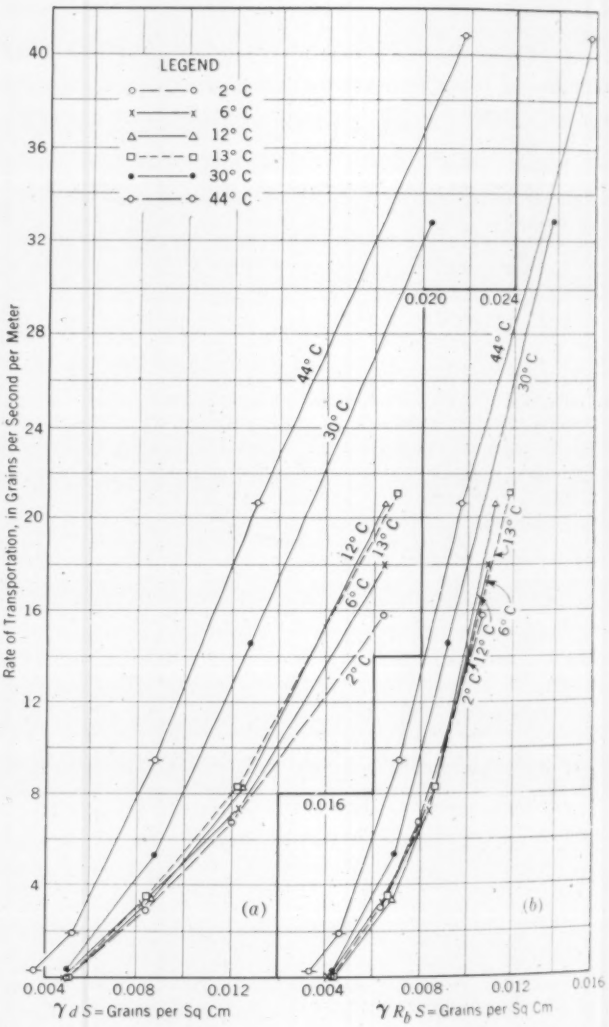


FIG. 2. ELIMINATION OF SIDE-WALL FRICTION IN EVALUATING EFFECT OF TEMPERATURE ON BED-LOAD TRANSPORTATION

tractive force is not an exact measure of the force causing transportation. The more reasonable method of presenting such data is to eliminate the influence of side-wall friction and compare the observations on the basis of channels of infinite width.

For example, by using the original data from which Fig. 2(*a*) was plotted, the hydraulic radius of the bed was computed for each run by the application of Eqs. 5 to 11, inclusive. The effective tractive force acting on the bed was then computed by Eq. 12 and plotted, as shown in Fig. 2 (*b*), against the corresponding rate of bed-load transportation. It is seen that the transportation curves for temperatures of 2, 6, 12, and 13 C practically coincide.

EFFECT OF TEMPERATURE DISCUSSED

The primary effect of temperature in these experiments appears to be in the effect of viscosity variations on the magnitude of the friction along the relatively smooth side walls. It is of interest to note that this effect would not be evident if the Manning formula were used to determine the side-wall effect, since viscosity is not considered. When the formula for flow in smooth pipes was used to evaluate side-wall friction, values of the hydraulic radius of the bed were found to be approximately 6% smaller than those values obtained by the Manning formula for depths at 2 in., and approximately 18% smaller for depths at 8 in.

Because of the failure to give consideration to the distribution of friction between the bed and the side walls under the various conditions in these experiments, the conclusion that temperature has a decided effect on bed-load transportation appears to be overestimated. In this example, as well as in many others, erroneous conclusions or apparent inconsistencies in certain data often may be explained by the variations in the friction loss over the cross section.

The author wishes to acknowledge the suggestions and assistance of Dr. H. A. Einstein in the preparation of this paper.

Earthwork Calculations Simplified

By F. F. FERGUSSON, ASSOC. M. AM. SOC. C.E.

SENIOR EXECUTIVE ENGINEER, PUBLIC WORKS DEPARTMENT, MARWAR STATE, JODHPUR, RAJPUTANA, INDIA

IN the course of studies for an entirely different purpose, I have devised a method of calculating earthwork quantities. It would not be surprising to learn that this method has been in use elsewhere, as it is so simple. It has been evolved in the course of my work, from the property of determinants.

Let Fig. 1 represent the cross section whose area is required, the coordinates having been computed from an assumed origin, as shown. The area can then be computed from the form

$$A=\frac{1}{2}\left[\begin{matrix}+10 & +20 & +15 & +7.5 & -10 & -40 & -10 & +10\\ 0 & +10 & +12.5 & +20 & +22.5 & +30 & 0 & 0\end{matrix}\right] \quad (1)$$

The quantities within the brackets are the coordinates of the points in the form of a fraction, taken in a counterclockwise order, beginning and ending with the same fraction, in this case the one at the lower right hand. Multiplications are now carried out as indicated by the arrows, those for full arrows being positive and those for dotted arrows negative. Then

$$A = {}^1/_2\{[100 + 250 + 300 + 168.75 + (-300) + (-0) + (-0)] \quad (2)$$

(*Full arrow multiplication*)

$$-[0 + 150 + 93.75 + (-200) + (-900) + (-300) + 0]\}$$

(*Dotted arrow multiplication*)

$$A = {}^1/_2(2{,}218.75 - 543.75) = 837.5 \text{ sq ft} \quad (3)$$

The method is derived from a consideration of the expression, in determinant form, for the area of a rectilineal figure. The area of the triangle in Fig. 2 is given by the expression

$$A = {}^1/_2\begin{vmatrix} x_1 & y_1 & 1\\ x_2 & y_2 & 1\\ x_3 & y_3 & 1\end{vmatrix} \quad (4)$$

which on being expanded becomes

$$A = {}^1/_2(x_1y_2 - x_2y_1 + x_2y_3 - x_3y_2 + x_3y_1 - x_1y_3) \quad (5)$$

This expression can also be written in the following form:

$$A=\frac{1}{2}\left[\begin{matrix}x_1 & x_2 & x_3 & x_1\\ y_1 & y_2 & y_3 & y_1\end{matrix}\right] \quad (6)$$

in which the multiplications are carried out as already described.

If we transform the axes in Fig. 2 so that the origin coincides with the apex x_3y_3 of the triangle and the x-axis with the side x_3y_3, x_1y_1, Eq. 5 is reduced to

$$A = {}^1/_2(x_1y_2) \quad (7)$$

since the terms x_1, y_1, and y_2 all have zero value.

The proof that Eq. 6 holds for the general case of a polygon of n sides is obtained as follows:
Let us take an n-sided figure as shown in Fig. 3.

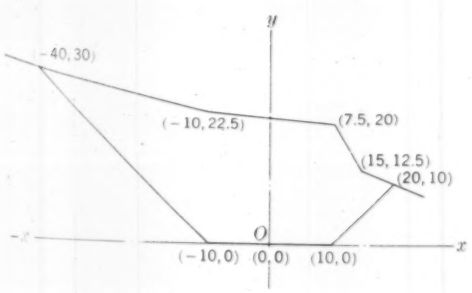


FIG. 1

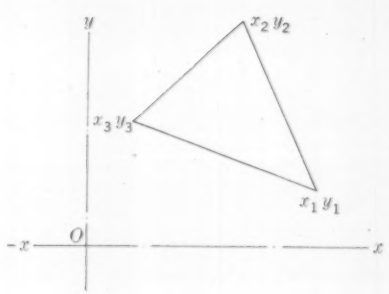


FIG. 2

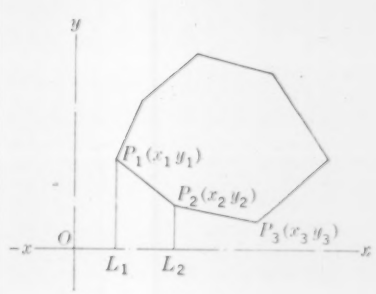


FIG. 3

The area of the trapezium $P_1L_1\,L_2P_2$ is given by the expression

$$A = {}^1/_2(y_1 + y_2)(x_2 - x_1) = {}^1/_2\begin{vmatrix} x_1 & x_2 \\ y_1 & y_2 \end{vmatrix} + {}^1/_2(x_2y_2 - x_1y_1) \quad \ldots(8)$$

the area of the whole figure can be found by summing the areas of such trapeziums, corresponding to the sides P_1P_2, $P_2P_3, \ldots P_{n-1}P_n$, the superfluous areas canceling out; thus

$$A = {}^1/_2\sum\begin{vmatrix} x_1 & x_2 \\ y_1 & y_2 \end{vmatrix} + {}^1/_2\sum(x_2y_2 - x_1y_1)$$

$$= {}^1/_2\,|\,x_1y_2 - x_2y_1 + x_2y_3 - x_3y_2 \ldots .\,|\,+\,0$$

$$= {}^1/_2\begin{vmatrix} x_1 & x_2 \ldots .x_n & x_1 \\ y_1 & y_2 \ldots .y_n & y_1 \end{vmatrix}$$

Editor's Note: A similar method for cross-section areas, based on summations for component triangles, was given in the May 1940 issue, page 311, and the August 1940 issue, page 530.

Beams with Moment of Inertia Doubled near the Ends

By ADOLPH BARJANSKY
CLEVELAND, OHIO

IN the course of a recent design study, the writer encountered beams having the property that their moments of inertia are doubled near the ends. This was effected by overlapping adjacent spans of a continuous beam. The analysis of systems of such beams by moment distribution required that fixed-end moments, carry-over and distribution factors be quickly and accurately obtainable. This purpose is accomplished by the curves given herewith. The fixed-end moment F was determined by considering a unit-length beam built in at both ends (Fig. 1, *a*), in which the double moment of inertia extends over the intervals whose abscissas are $0 < x < a$ and $b < x < 1$. Considering the beam to be uniformly loaded, F is determined by applying the two moment-area principles, and the result is

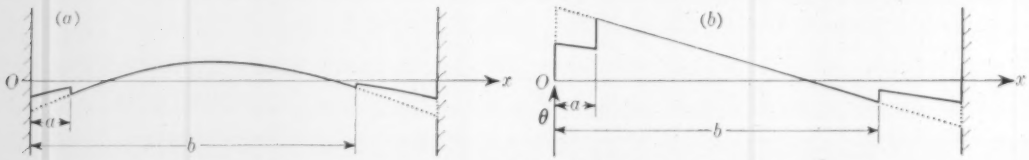


FIG. 1. BEAM LAYOUTS

$$F = \frac{1}{2}\,\frac{\left(\frac{1+b^3-a^3}{3}\right)^2 - \left(\frac{1+b^2-a^2}{2}\right)\left(\frac{1+b^4-a^4}{4}\right)}{\left(\frac{1+b^2-a^2}{2}\right)^2 - (1+b-a)\left(\frac{1+b^3-a^3}{3}\right)} \quad \ldots(1)$$

The carry-over and distribution factors C and K are determined in a similar way with the help of Fig. 1 (*b*) (see, for instance, L. E. Grinter, *Theory of Modern Steel Structures*, Vol. 2, p. 242), which shows the unit-length beam of Fig. 1 (*a*) with reinforced portions determined as before by abscissas a and b. The right end is built in, while the left end is simply supported and subjected to a unit couple. Then the carry-over factor C is the resulting moment at the right end.

If the rotation at the supported end is θ, its reciprocal $1/\theta$ is a measure of the distribution factor K. For a non-reinforced beam, $a = 0$, $b = 1$, $\theta = \theta_0 = {}^1/_4$. Then let K be defined as $1/\theta \div 1/\theta_0 = \theta_0/\theta = {}^1/_4\theta$. Again using the two moment-area principles, the following expressions are found:

$$C = \frac{3(1+b^2-a^2)}{2(1+b^3-a^3)} - 1 \quad \ldots(2)$$

$$K = \frac{1}{2(1+b-a) - \frac{3}{2}\,\frac{(1+b^2-a^2)^2}{(1+b^3-a^3)}} \quad \ldots(3)$$

Equations 1, 2, and 3 are plotted in Figs. 2, 3, and 4, respectively. These curves give the value of F, C, and K, without any involved computations.

Since the beams considered are not necessarily symmetrical, F, C, and K as read on the curves are the values at the end from which a and b are measured. To obtain the values at the opposite end, the origin must be taken there; that is, the far-end constants F', C', and K' are read off the same curves using $a' = 1 - b$ and $b' = 1 - a$. This will be illustrated in the example to follow.

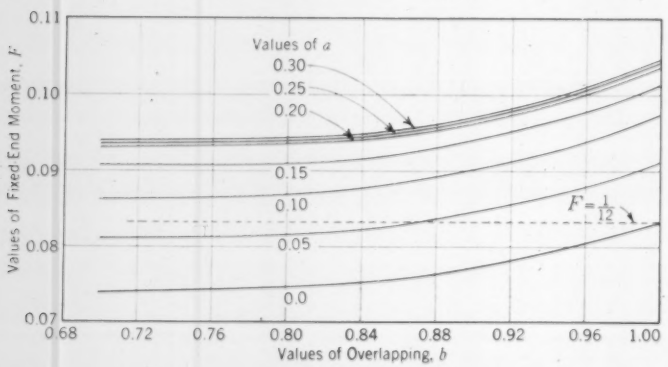


FIG. 2. GRAPHS FOR FIXED-END MOMENT F

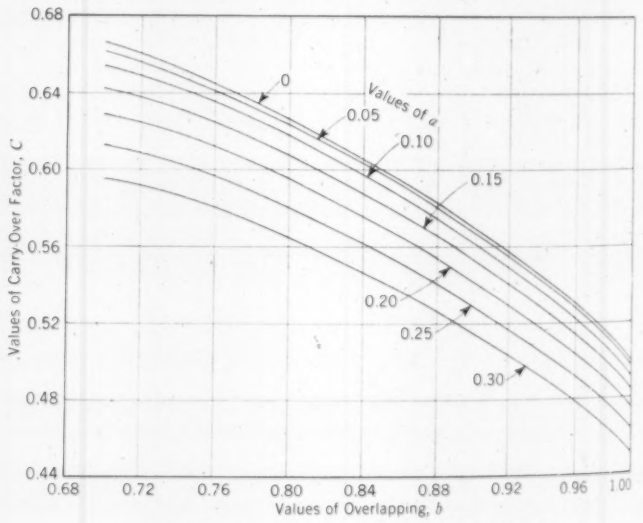


FIG. 3. GRAPHS FOR CARRY-OVER FACTOR C

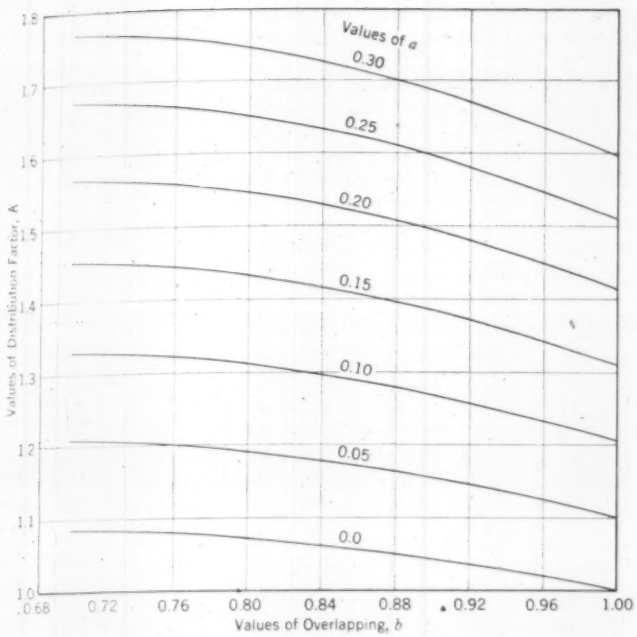


FIG. 4. GRAPHS FOR DISTRIBUTION FACTOR K

The factors C and K are independent of the loading on the beam and can therefore be used quite generally. The value of F, however, is a function of the external loads, and both Eq. 1 and Fig. 2 represent the common case of uniform loading. For a concentrated load, F would depend not only on a and b, but also on the abscissa u of the load, or on a total of three independent variables, so that a representation by one family of curves is impossible. A nomogram could probably be constructed, but the formulas in question are of such a form that the labor involved was judged to be disproportionate with the expected use. The formulas are therefore given without further elaboration:

$$u < a < b \qquad F = \frac{S_2\left(\frac{u^3}{6} - uS_2 + S_3\right) - S_3\left(\frac{u^2}{2} - uS_1 + S_2\right)}{S_1S_3 - S_2^2}; \quad F =$$

$$a < u < b \qquad \frac{S_2\left[\frac{u^3}{6} + \frac{u^2}{2} - u\left(b + \frac{1}{2}\right) + \frac{2 + 3b^2}{6}\right] - S_3\left[u^2 - u(1 + b) + \frac{1 + b^2}{2}\right]}{S_1S_3 - S_2^2};$$

$$a < b < u \qquad F = \frac{S_2\left(\frac{u^3}{6} - \frac{u}{2} + \frac{1}{3}\right) - \frac{S_3}{2}(1 - u)^2}{S_1S_3 - S_2^2} \qquad (4)$$

$$\text{with } S_n = \frac{1 + b^n - a^n}{n}$$

Here u is the abscissa of the concentrated load, counted from the same end as a and b.

Example. Let us assume a beam MN, with moment of inertia doubled on 10% of its length near M, and on 20% near N. Then, for the factors at M, $a = 0.1$, $b = 0.8$. From Figs. 2, 3, and 4 we read $F = 0.087$, $C = 0.617$, and $K = 1.55$. These are the fixed-end moment and the distribution factor for end M, and the carry-over factor from M to N. To find the factors at N, the origin is transported there, so that a and b become $a' = 0.2$ and $b' = 0.9$. Using these new values, the following readings are obtained from the same curves: $F' = 0.096$, $C' = 0.532$, and $K' = 1.27$. These are the fixed-end moment and the distribution factor at N, and the carry-over factor from N to M.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Coordinating Design and Construction Methods on Chicago Subway

TO THE EDITOR: The able paper by Peter F. Girard, in the March issue, cites some trenchant examples of the importance of coordinating design and construction in the building of the Chicago Subway.

In the early days of the twentieth century London, Paris, New York, Boston, Philadelphia—even Madrid, Buenos Aires, and Tokyo—found relief from their transportation and traffic problems in a system of subways. Chicago made a slightly different approach to the situation by authorizing the construction of the Illinois Tunnel System of freight tunnels under its downtown streets. Coal, ashes, and miscellaneous freight are hauled between Loop office buildings, hotels and department stores, and outlying freight terminals and storage yards. Nevertheless, the city made comprehensive designs for a system of subways similar to those in other cities. Many factors, chiefly financial, held these plans in abeyance until November 3, 1938.

When it is realized that the project started almost from scratch and that it was necessary to prepare many designs and estimates before a selection of the types to be used could be made, it can be seen that no time was lost in getting started. Organization of the work proceeded simultaneously with the drawing of plans and specifications. The substantial completion of the construction problem in the allotted 20-month time limit is due to the coordination of these two functions. About 25 separate major contracts were involved in the tunnel and station work and 20 more for miscellaneous work. It is said that the construction of the Chicago subway has set a new record for speed.

A section of the Division of Surveys that came under my supervision is Building Examination. The function of this department is to determine the physical condition of every building and piece of property abutting the right-of-way of the two subway routes, before, during, and after completion of construction. In several cases the conditions disclosed affected construction procedure.

To ascertain these conditions we examined and secured photographs of approximately 2,000 buildings. Each examiner detailed to the work was accompanied by a photographer. They visited each room in the structure under inspection, made a record of the condition of the walls, floors, ceilings, and equipment, and took 4 by 5-in. photographs. In addition to this, they took 8 by 10-in. photographs of the exteriors of the building prior to the construction in the vicinity. A second set of 8 by 10-in. photographs was taken when and if the building was re-examined, and another set when the final examination was made. In all, two or three sets of notes and photographs pertaining to the exterior and interior of each building are filed in the division vaults. Close-ups of damaged walls and foundations and close-ups of sidewalks and curbs show the condition of these structures before, during, and after construction of the subways. The Construction Division takes similar photographs of subway construction in progress and upon completion.

Before construction began owners were notified to care for their buildings, and were invited to be present at the physical examination. The examinations were made jointly with a representative of the contractor involved. Less than 5% of the frontage along the subway routes was shored by the owners of the property. The city shored only those buildings located over the tubes.

The successful outcome of the project is the result of the efficient cooperation of the design and construction divisions.

FRANK A. RANDALL, M. Am. Soc. C.E.
Consulting Structural Engineer

Chicago, Ill.

Closure of Discussion on Cable-Sag Calculations

DEAR SIR: In the April number of CIVIL ENGINEERING, Mr. Meals offers a solution in the form of a cubic equation for the problem (cable-sag calculations) for which the writer suggested a method in the February number. Where Mr. Meals differs from the original answer, in the second part of the problem, one may examine his results to see if they are self-consistent.

The ΔL for the first state was 3.16 ft. To get the ΔL for the last state we add $30 \times 883 \times 0.00001 = 0.265$ ft because of the rise in temperature, and since the horizontal tension is decreased by $4{,}500 - 3{,}487 = 1{,}013$ lb we subtract $\frac{1{,}013 \times 883}{0.2367 \times 11{,}415{,}000} = 0.331$ ft, giving $\Delta L = 3.094$ ft for the third state. From Mr. Meals, figures, $\Delta L = \frac{8}{3}\frac{28.73^2}{880} = 2.5$ ft. This rather sharp discrepancy between the ΔL's indicates an error somewhere in the procedure, possibly in the solution of the cubic equation. The writer avoids cubic equations where this avoidance is more convenient, and so has not checked Mr. Meals' equations. The writer's method is self-checking.

Incidentally, I should like to call attention to an error in the last paragraph of my article in the February issue—2.957 should be 2.967, and 2.988 should be 2.998. The result is not affected. A 10-in. slide rule is adequate for such work.

C. M. GOODRICH, M. Am. Soc. C.E.
Consulting Engineer, the Canadian Bridge Company, Ltd.

Walkerville, Canada

Legislation Cannot End Depressions

DEAR SIR: From articles and discussions in recent issues of CIVIL ENGINEERING it is evident that there is a difference of opinion as to the cause of major financial depressions such as that which started in 1929.

A study of history will show that all major depressions have been preceded by several years of excessive speculation in stocks, real estate, or commodities by the public at large. Certainly the high prices of stocks on the New York Stock Exchange in the late twenties were not the result of a cold intellectual analysis of past, present, and prospective earnings of corporations, whose stocks were sky-rocketed by the emotional impulse of a large part of our people to get rich quick, or to get something for nothing—traits common to most of us. For example, the stock of one of the largest and strongest banks in New York, which was earning 7% and paying 4 sold at $550 per share in 1929. In recent years it has been selling around $25. The stock of an automobile company, since gone into bankruptcy, sold at $500 per share in 1929, and a long list of similarly extravagant prices could be cited.

A study of history will show that inordinate speculation is not confined to our own country or to our own century, for just as serious depressions occurred in Holland in the early seventeenth century and in England and France in the early eighteenth century—all brought on by over-speculation.

Referring to Holland, the word tulipomania has been given to the craze for the purchase of tulips at prices far beyond their true worth. The rage for possessing tulips permeated all classes of society. Nobles, farmers, mechanics, seamen, footmen, maid-servants, even chimney-sweeps and old-clothes men gambled in tulips. This wide distribution of speculators was duplicated in 1929 when elevator men, stenographers, clergymen, and other people of small means speculated in stocks. At first, as in all gambling manias, everybody gained. Then, as in all cases of speculation, confidence was finally destroyed and universal panic ensued. Substantial merchants were reduced almost to beggary, and many a noble saw the fortunes of his house dissipated. As a result of this mania the commerce of Holland received a severe check from which it took many years to recover.

The South Sea Bubble was the name given to a series of speculative projects in England which culminated in disaster. The rapid swing from exaltation to depression was revealed in a popular doggerel of 1720:

> My shares which on Monday I bought
> Were worth millions on Tuesday I thought.
> So on Wednesday I chose my abode;
> In my carriage on Thursday I rode;
> To the ballroom on Friday I went;
> To the workhouse next day I was sent.

Naturally this inordinate speculation was followed by a serious business depression.

In France in 1716 John Law originated the so-called Mississippi Scheme, in the stock of which there was great speculation on the part of the public. Finally a serious depression ensued, and Law had to flee to Italy to save his life.

Since the control by law of individual speculative impulse is impossible, I am not hopeful that any legislation can prevent such speculation in our form of government, which has permitted the individual to use his own judgment in buying and selling and which, notwithstanding several serious depressions, has brought about the highest standard of living ever known. Perhaps under an autocratic form of government, depressions could be prevented, but in that case the cure might be worse than the disease.

PHILIP W. HENRY, M. Am. Soc. C.E.
Consulting Engineer

New York, N.Y.

Approximate Water-Hammer Formulas

TO THE EDITOR: In computing pressure rise for speed regulation of turbines, it is quite usual to use an approximate water-hammer formula for the purpose of avoiding the labor of exact computations. Of the approximate formulas that have been suggested, probably the most useful for the purpose stated is the rigid-column formula of R. D. Johnson:

$$\Delta H = \frac{LV}{2g^2HT^2}\left[LV + \sqrt{4g^2H^2T^2 + L^2V^2}\right] \quad \ldots\ldots (1)$$

where ΔH = pressure rise in feet; L = length of conduit; V = velocity at beginning of closure; H = static head in feet; and T = equivalent closure time.

Dividing both sides by H, this formula can be readily converted into the form given by Creager and Justin for pressure rise in their *Hydroelectric Handbook*, namely:

$$\frac{\Delta H}{H} = \frac{n}{2}\left[n + \sqrt{n^2 + 4}\right] \quad \ldots\ldots (2)$$

where $n = \frac{LV}{gTH}$. This formula gives very good results for relatively slow closures and moderate heads, or roughly speaking, for closure in more than about four intervals of $\frac{2L}{a}$ where a = velocity of propagation of wave and for heads less than fifty times the velocity in feet per second.

If values of $100\,\frac{\Delta H}{H}$, or per cent pressure rise, are plotted on logarithmic paper from Eq. 2 against a base of values of $\frac{LV}{TH}$, it will be found that the percentage of pressure rise can be expressed very nearly by the following expression

$$p = 100\,\frac{\Delta H}{H} = 2.9\left(\frac{LV}{TH}\right)^{1.1} \quad \ldots\ldots (3)$$

This formula (Eq. 3) has the advantage of being simple, easily remembered, and easily computable on the ordinary log log slide-rule without recourse to any table or diagrams

Two illustrative examples are given for comparing the results of Eq. 3 with values calculated by exact methods. From the U.S. Bureau of Reclamation's "Penstock Analysis and Stiffener Design" (Table IV, page 130), L = 1,660 ft; V = 15.07 ft per sec; T = 5 sec; and H = 571 ft. By Eq. 3, p = 31.4%; by Allievi's formula at two intervals $p = \frac{179.31}{571} \times 100 = 31.4\%$; and by Allievi's formula at 4 intervals $p = \frac{178.14}{571} \times 100 = 31.2\%$.

From page 118 of the A.S.M.E. "Symposium on Water Hammer" (published in 1933), L = 1,127 ft; V = 17.58 ft per sec; T = 17 sec; and H = 161.6 ft. By Eq. 3, p = 25.3%, and by Allievi's formulas $p = \frac{17.3 \times 144 \times 100}{62.5 \times 161.6} = 24.7\%$

In view of the number of erroneous and misleading formulas for water hammer put forward from time to time, the writer wishes to state specifically that Eq. 3 is not a new water-hammer formula, but a nutshell version of Johnson's well-tried approximate formula, which gives correct results only within certain limits as stated. It is recommended only for preliminary water-hammer computations such as for speed regulation, for full load off (also in most cases for half load off), and for heads under about 600 ft.

ROBERT A. SUTHERLAND, Assoc. M. Am. Soc. C.E.
Wilmette, Ill.

Diagram for Hydraulic Jump

DEAR SIR: The article by Clarence Freeman on "Nomograph for Computing Elevations of Stilling Basin Aprons," in the March issue, is of interest to anyone who has had occasion to analyze the hydraulic jump occurring below a spillway.

Some time ago, I attempted to construct a diagram which would present the requirements for the formation of the hydraulic jump below spillways. Referring to Fig. 1, the required formulas are:

$$H = \frac{q^2}{2gd_1^2} + d_1 - d_2$$

$$H = \frac{2q^2}{gd_2^2\left(\sqrt{\frac{8q^2}{gd_2^3} + 1} - 1\right)^2} + \frac{d_2}{2}\left(\sqrt{\frac{8q^2}{gd_2^3} + 1} - 1\right) - d_2$$

in which

H = Difference in elevation between upper pool and tailwater in ft
q = Discharge per foot of spillway crest width in cu ft per sec
d_1 = Depth above the hydraulic jump in ft
d_2 = Depth below the hydraulic jump in ft
g = Acceleration due to gravity, 32.2 ft/sec²
$F^2 = \frac{q^2}{gd_1^3}$

After working up the data into several forms, the diagram Fig. 2 was adopted and subsequently has proved to be quite valuable in the reduction of hydraulic computations. The diagram may be of interest, since the construction is based upon the theoretical equation for the elevation of stilling basin aprons.

It does not include friction losses. Compensation for friction may be made by subtracting the equivalent friction head from H, the difference between upper and lower pool elevations, before entering into the diagram. The line $F^2 = 3$ or $\frac{d_2}{d_1} = 2$ marks the boundary between jumps of the undular and shock types. Model studies indicate that a strong hydraulic jump forms in the region to the right of $F^2 = 12$, or $\frac{d_2}{d_1} = 4.42$.

In addition to expediting the solution for the hydraulic jump below a spillway, Fig. 2 possesses certain advantages in the determination of related factors in the ordinary hydraulic-jump problem. Furthermore, it is to be noted that the parameters d_2/d_1 are lines denoting similarity of conditions, consequently, values for prototype and model may be compared by referring to values falling along these lines.

For the solution of special problems, it may be advantageous to superimpose on the diagram parameters for values of velocities or for values of $H+d_2$. These parameters were omitted intentionally from the diagram to avoid confusion in reading the curves.

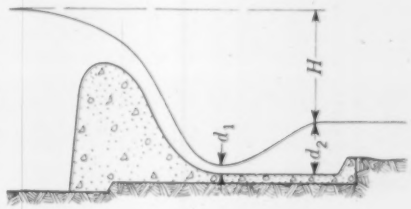


FIG. 1

The writer wishes to acknowledge the cooperation of R. G. West in direct supervision of the work, of B. R. Gilcrest for his suggestions and check of the diagram, and of R. E. Freese in preparation of the drawing. The work was done under the direction of Col. C. L. Hall, Division Engineer, Ohio River Division.

RAYMOND L. IRWIN, Assoc. M. Am. Soc. C.E.
Associate Engineer, Ohio River Division, U.S. Engineer Office
Cincinnati, Ohio

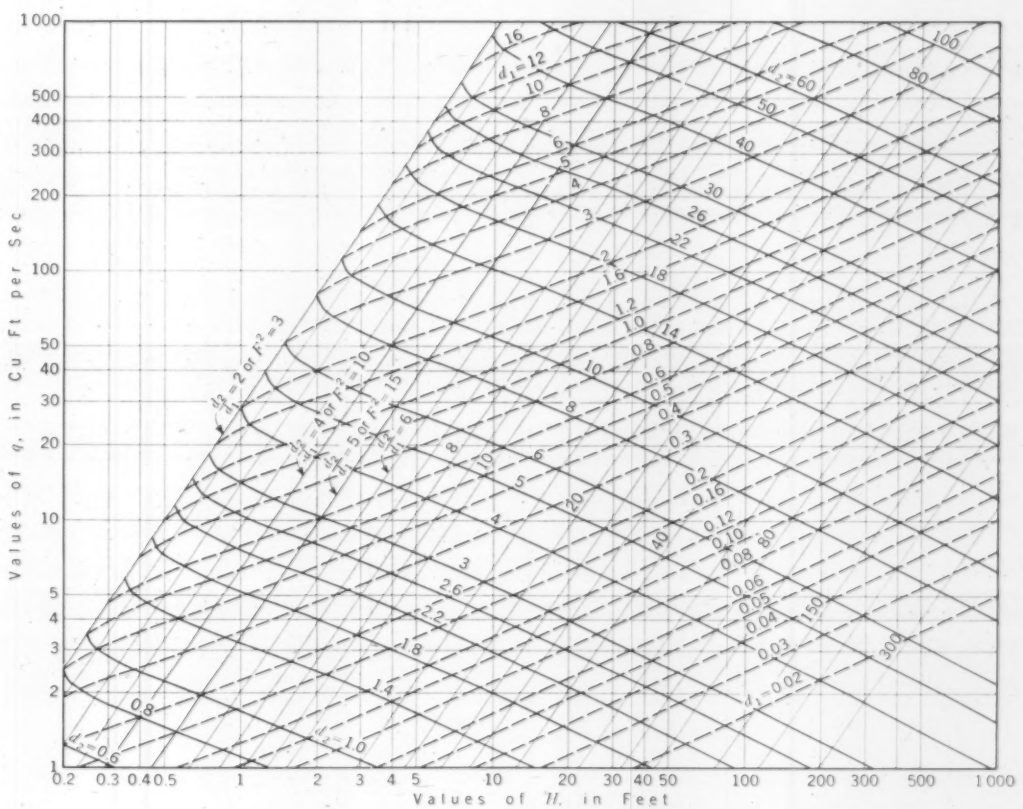


FIG. 2

SOCIETY AFFAIRS

Official and Semi-Official

Advance Planning for Summer Convention

At University of Minnesota, Minneapolis, July 22 and 23, 1942

WITH THE DECISION of the Board of Direction to proceed with the Society's Summer Convention in Minneapolis, as determined at the Roanoke Meeting, plans for this coming meeting are energetically going forward. The dates are Wednesday and Thursday, July 22 and 23, 1942.

All sessions will be held at the University of Minnesota. This means not only the technical gatherings but also the Board and committee meetings that will precede the convention proper. General headquarters at the University will be in the Coffman Memorial Union, a new and spacious two-million-dollar structure. Here also will be held all the meetings of the Society, including the Wednesday evening dinner and the programs of the Technical Divisions. Six single or half-day sessions have been planned by as many Divisions. The following subjects for discussion have been suggested to the Divisions for elaboration in series of papers:

City Planning—Aspects of Migration of Population and Emergency Housing

Construction—Developments of New Construction Equipment and Adjustment of Old Equipment to New Uses

Hydraulics—Hydraulic Problems in the Water Supply of Army Camps

Sanitary Engineering—Engineers' Responsibility Relative to Wartime Protection of Sewerage Facilities

Structural—Structural Methods in Shipbuilding; Saving Steel in Structural Design

Surveying and Mapping—Surveying Methods Used on the Alaska Highway

A session on Wednesday afternoon will be sponsored by the Society's National Committee on Civilian Protection in Wartime, which will conduct round-table discussions on evacuation routes, camouflage of airports and industrial plants, and a colloquy on what Local Section Committees on Civilian Protection have achieved.

A point of special technical interest is the nearby Hydraulic Laboratory of the University, within walking distance of headquarters. The session of the Hydraulic Division will be held there, and the building will be a center of interested inspection during the meeting.

ACCOMMODATIONS FOR ALL

Holding most of the sessions at the Coffman Memorial Union Building will make for convenience as well as sociability. This building is about five minutes' walk from another up-to-date structure, the Center for Continuation Studies, which will provide ample accommodations for Board and committee meetings. In addition to a fine auditorium and committee rooms, the Center has a self-contained residence hall, with provisions for sleeping and dining ample to take care of the Board and Society officers for their stay, beginning on Sunday, July 19. As far as the Board is concerned, this building will therefore take the place of the ordinary hotel headquarters.

For those members and guests who bring their families, or who may desire regular hotel accommodations, the Hotel Nicollet in the business district of the city, some mile and a half distant, will be found convenient. This hostelry, which has an excellent reputation for appointments and hospitality, will be designated "Hotel Headquarters," as distinguished from the "Meeting Headquarters" at the Coffman Memorial Union Building.

Still another class of visitor is provided for. A new men's dormitory, Pioneer Hall, will have space for up to 200 men at reasonable rates. The quarters consist of separate rooms now forming part of student suites, made up of two bedrooms separated by a common study. Pioneer Hall is five minutes' walk from the Coffman Memorial Union Building.

LOCAL SECTION CONFERENCE

On Tuesday, July 21, there will be an all-day conference of representatives from the western Local Sections. The following 27 Sections will participate in this conference:

Arizona	Kansas City	San Diego
Central Illinois	Los Angeles	San Francisco
Colorado	Mid-Missouri	Seattle
Duluth	Nebraska	Spokane
Hawaii	New Mexico	Tacoma
Illinois	Northwestern	Tri-City
Indiana	Oregon	Utah
Iowa	Sacramento	Wisconsin
Kansas	St. Louis	Wyoming

All members of the Society interested in this conference are invited to be present and participate in the discussion. The

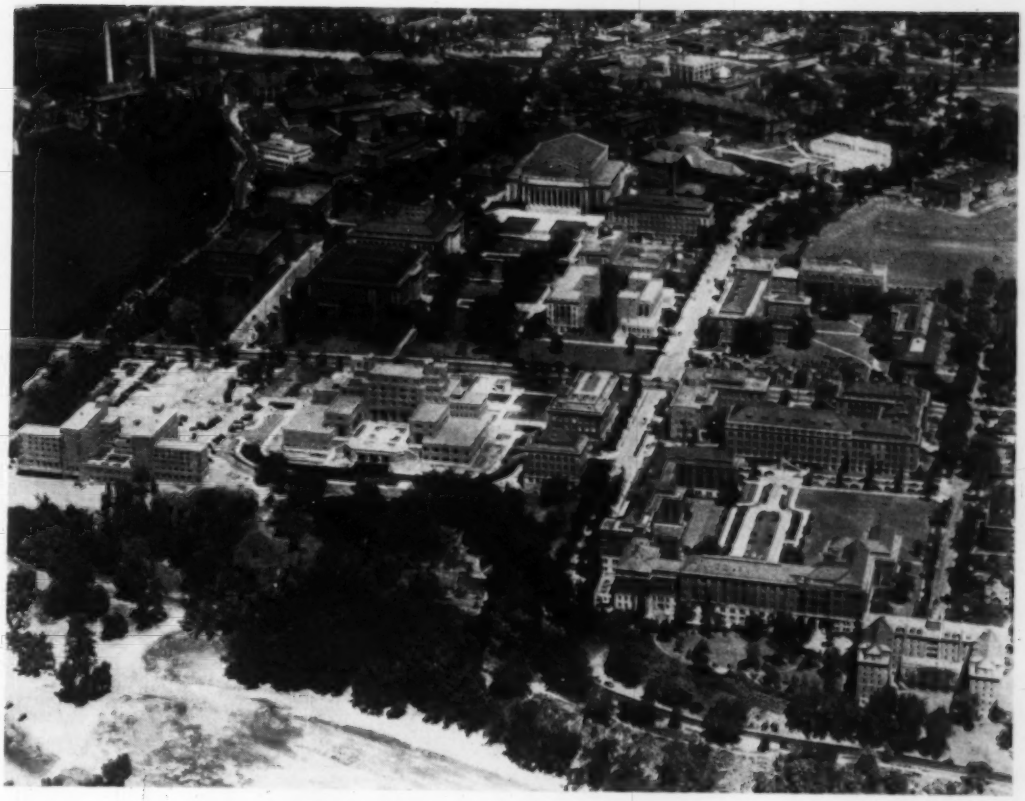
HYDRAULIC LABORATORY OF THE UNIVERSITY OF MINNESOTA AT ST. ANTHONY'S FALLS ON THE MISSISSIPPI
Of Special Interest to Those Attending the Convention

general topics will be civilian protection activities of Local Sections; effects of unionization on the engineering profession; and most effective war-time work of Local Sections.

Off the Record

In spite of the war restrictions placed on tires, cars, and railroad travel there are more reasons than usual for civil engineers to confer together in technical meetings. The war imposes a certain amount of censorship on technical material that can be published without aiding the enemy. Some of the information presented must be "off the record."

It cannot be read later. It is presented in session for the purpose of providing members with information that will enable them to do a better job of helping the Government win the war. Members who are unable to attend will lose this opportunity to keep abreast of engineering developments. Construction, in both volume and rate, exceeds figures ever before reached. New equipment, new methods, new procedures, and unprecedented speeds are being developed continually.



University of Minnesota, Headquarters of the Summer Convention

Additional Attractions Are Offered

A number of supplementary features will add special interest to this summer meeting. It takes place, for example, during the week when the annual event called the Aquatennial is held in Minneapolis. This will appeal to the ladies and to engineers who may wish to make something of a vacation period out of the days preceding or following the Convention. The Aquatennial is a time of festivity, with colorful parades, rodeos, and regattas. During 1942 the war theme will be uppermost.

Main Lounge of the Coffman Memorial Union, Where Meeting Sessions Will Be Held

Mention has been made of the Hydraulic Laboratory. It is at a picturesque site on the Mississippi River—St. Anthony's Falls. Besides means for measuring large quantities of water, it also offers facilities for large-scale tests of hydraulic models of all kinds. Also connected with the University are a testing laboratory, a highway research laboratory, and other facilities of special interest to visiting engineers. Also of interest is the large sewage disposal plant recently completed for Minneapolis.

As a social center for a normal enrolment of some 14,000 students, the Coffman Memorial Union is complete in every way. It has attractive lounges, a grand ballroom, dining rooms, and cafeterias, as well as bookstore, billiard room, game room, and bowling alleys. A large underground garage is attached. Facilities for banquets and regular meals are ample. There are no rooming accommodations except as a part of a Faculty Club on the top floor.

Rail Facilities Are Ample

Minneapolis and its sister city, St. Paul, comprise a natural railroad center with trunk lines radiating in all directions. Accordingly the Summer Convention will be one that is easy to reach by the means that will be most popular. A dozen comfortable trains leave Chicago for Minneapolis daily. Nearer visitors may find they can come by highway in spite of war limitations. For the larger group that will depend on the railroad, a brief summary of railroad schedules serving Minneapolis is appended:

From Chicago to Minneapolis

Via Chicago & North Western RR

	The Viking	The "400"	The Victory	The North Western Ltd.
Lv. Chicago.....	9.30 a.m.	3.00 p.m.	9.50 p.m.	11.00 p.m.
Ar. Minneapolis..	7.55 p.m.	9.45 p.m.	8.25 a.m.	8.35 a.m.

Via Chicago, Milwaukee, St. Paul & Pacific RR

	Hiawatha	Hiawatha	Pioneer Ltd.	Olympian
Lv. Chicago.....	9.45 a.m.	1.00 p.m.	10.15 p.m.	11.15 p.m.
Ar. Minneapolis..	5.45 p.m.	7.45 p.m.	8.00 a.m.	9.10 a.m.

Via Chicago, Burlington & Quincy RR

	Zephyr	Zephyr	Black Hawk	North Coast	Empire
Lv. Chicago	9.00 a.m.	3.30 p.m.	10.00 p.m.	11.00 p.m.	11.15 p.m.
Ar. Minneapolis	3.30 p.m.	10.15 p.m.	7.55 a.m.	9.05 a.m.	9.20 a.m.

From Omaha to Minneapolis

Via Chicago & North Western RR

	North American	Nightingale
Lv. Omaha	8.42 a.m.	9.35 p.m.
Ar. Minneapolis	7.50 p.m.	8.10 a.m.

Via Chicago Great Western RR

		Twin Cities Ltd.
Lv. Omaha	8.45 a.m.	9.00 p.m.
Ar. Minneapolis	8.10 p.m.	7.40 a.m.

From Kansas City to Minneapolis

Via Chicago, Rock Island & Pacific RR

	Rocket	
Lv. Kansas City	11.10 a.m.	8.30 p.m.
Ar. Minneapolis	8.08 p.m.	8.30 a.m.

From St. Louis to Minneapolis

	Zephyr-Rocket	
Lv. St. Louis	5.30 p.m.	*C.B. & Q.*
Ar. Minneapolis	7.30 a.m.	*C.R.I. & P.*

Note: The "400," the Hiawathas, and the Zephyrs are streamliners.

General plans for the Convention, so far perfected, ensure that it will live up to the high standards of Society gatherings. There will be limited social events, but as always the friendly contacts of old and new acquaintances will be one of the features. The technical program and the President's Annual Address will serve as the focus. The engineering features will be devoted almost exclusively to presentations aimed to assist engineers in their best efforts to help the Government win the war. Full details will be given in the final program, to appear in the July issue.

Meeting of Board of Direction—Secretary's Abstract, April 20, 1942

THE Board met at the Hotel Roanoke, Roanoke, Va., on Monday, April 20, 1942, with Vice-President Charles B. Burdick in the chair, and Secretary Seabury and the following members of the Board in attendance: Past-Presidents Hogan and Fowler; Vice-Presidents Stevens, Spofford, and Stanton; and Directors Blair, Boughton, Carey, Cowper, Cunningham, Dickinson, Dunnells, Goodrich, Howard, Hyde, Lilly, McNew, Polk, Rawn, Requardt, White, Wiley, and Treasurer Trout. Regrets were received from President Black and Directors Burpee and Massey, all prevented from attendance by pressure of war work.

Approval of Minutes

The minutes of the meetings of the Board of Direction for January 19–20 and for January 22, 1942, and those of the Executive Committee for January 22, 1942, were approved. Slight corrections were noted in the minutes of January 19.

Reappointment—Secretary and Treasurer

As required by the Constitution, the appointment of a secretary and treasurer for the forthcoming year was in order. The incumbents, George T. Seabury, Secretary, and Charles E. Trout, Treasurer, were unanimously reappointed.

Minutes of Society Meeting, March 18

Records were presented covering the special Society meeting on March 18 at Society Headquarters, held for the sole purpose of canvassing ballots on an amendment to the Constitution. Report was received, including the results of the ballots canvassed, indicating adoption of an amendment to the Constitution regarding Junior membership and dues. (Details were given in the April issue of CIVIL ENGINEERING, page 223.)

Local Section Constitutions

Approval was given to certain proposals looking toward amendment of the constitutions of the following Local Sections:

Arizona Section	Georgia Section
Buffalo Section	Sacramento Section

Memoirs of Honorary Members

The Board was notified of the loss of A. N. Talbot, Past-President and Honorary Member of the Society, who died on April 3, 1942. To prepare a memoir the following committee was appointed: Messrs. Daniel W. Mead, Henry E. Riggs, and F. E. Turneaure, Honorary Members, and M. L. Enger, M. Am. Soc. C.E.

Announcement was also made of the death of Alex Dow, Honorary Member, on March 22. Henry E. Riggs, Honorary Member, was appointed chairman of a committee to prepare a memoir.

Committee on Meteorological Data

Upon request of the Committee on Meteorological Data, Donald M. Baker, M. Am. Soc. C.E., chairman, approval was given for the discharge of that committee. This was accompanied by a unanimous vote of thanks for the effective work this committee has accomplished.

Chemical Engineers in Joint Conference Committee

Concurring with action of the other Founder Societies, the American Institute of Chemical Engineers was invited to become a participant in the Joint Conference Committee, with its president and secretary as representatives.

Payment of Dues

Rules were adopted covering the payment of dues by those in arrears; for remission in certain cases of those of members in countries and parts of the United States affected by the war; and for payment from English speaking countries as affected by exchange rates.

Freeman Scholarship Withheld for 1942

In agreement with the recommendation of the Committee on the Freeman Scholarship, it was decided that no award from this fund shall be made this year.

Assistance from Engineering Foundation Requested

Requests were received from the Hydraulics and the Soil Mechanics and Foundations Divisions that they be accorded financial assistance in prosecuting research work through Division committees. The Board approved the requests and directed that they be transmitted to the Engineering Foundation.

ENJOYING THE REVIEW OF THE CADET CORPS, VIRGINIA MILITARY INSTITUTE
Members of Society Party at the time of the Roanoke Meeting

Summer Meeting

Approval was given for the holding of the Summer Meeting of the Society on the University of Minnesota campus in the week of July 19, 1942. Notice was given in the May issue, page 279, and further details are included on another page of this number. Decision as to the holding of a meeting of the Society in the fall was reserved until the Board meeting in July.

Inter-American Engineering

In accordance with similar action by other Founder Societies, the Board agreed to appoint a committee of three to act jointly with regard to inter-American engineering cooperation in connection with the Inter-American Development Commission.

Budget

Revision of the budget was adopted as it concerned both income and outgo. It was found possible to authorize the complete printing of the 1942 TRANSACTIONS; and at the same time the budget was brought substantially into balance.

Banking Society Funds

Resolutions were adopted providing for the proper banking and handling of Society monies.

Attacking Employment Problems

The Board received a report of its Committee on Employment Conditions, indicating active study; and in accordance therewith approved of the following continuing procedure:

1. Gathering and publishing of classification of positions and recommended salary schedules.
2. Aid in adjusting disputes and correcting discriminatory practices.
3. Special attention to the needs of engineers in subordinate positions and of Juniors.

New Members

The Committee on New Members reported regarding procedures it believed could well be followed in approaching engineers of distinction with regard to Society membership. Details are given in a separate item elsewhere in this issue.

Other Matters

Reports were received from committees regarding Publications, Professional Conduct, Membership, Washington activities, and a variety of other matters, with appropriate action taken in each instance.

Adjournment

The Board adjourned at the end of Monday afternoon, April 20, to meet at Minneapolis, Minn., on Monday, July 20, 1942.

Employment Problems Receive Special Attention

For many years the Society has been concerned with the economic welfare of its members, particularly the younger men of the profession. It is only recently, however, that it has established a procedure directed specifically toward the betterment of employment conditions.

The Committee on Salaries has developed, and the Board of Direction has approved, and promulgated, a Grading Plan and Compensation Schedule (see CIVIL ENGINEERING for September 1939). This deals with the pre-professional grades, as well as with those lower professional grades in which the younger men of the profession naturally find themselves.

Another material contribution was made to three large and specific problems in the West. In 1940 and in 1941, Allen P. Richmond, Jr., of the Society's staff, visited Arizona, Nevada, and Nebraska, where he studied certain state salary problems. As a result he was able to recommend grade classifications and related salaries for the engineering employees of the highway departments of these three states. His efforts were decidedly successful. The methods devised are incorporated in Manual 24 on "Surveys of Highway Engineering Positions and Salaries."

Now, by recent action, the Board of Direction has appointed a Committee on Employment Conditions. To aid this committee, Howard F. Peckworth, who for the past year has been editor of CIVIL ENGINEERING, has been assigned to the full-time study of employment conditions with relation to civil engineers.

Since March 1 he has made a special study of a particular situation—that wherein employees are banded together in some sort of formal organization for the purpose of remedying employment conditions. This search has disclosed certain associations of engineers recognized by authorities. In some cases they operated as independent units and in others they were affiliated with the larger national trade unions. Mr. Peckworth has been making a study of their methods and practices.

As of June 1 he is completing his third inspection trip. It has taken him to Kansas, Denver, Salt Lake City, Seattle, Portland, Tacoma, Sacramento, San Francisco, Los Angeles, Phoenix, El Paso, and New Orleans. Earlier trips were to the District of Columbia, Knoxville, and the South; also to the Middle West—Chicago, Iowa, Nebraska, Minnesota, and so forth. He is to devote his full time to these and similar employment problems.

Delegate Reports on Annual Meeting of American Academy of Political and Social Science

"WINNING Both the War and the Peace" was the general subject of the Forty-sixth Annual Meeting of the American Academy of Political and Social Science, held at the Benjamin Franklin Hotel in Philadelphia on April 10 and 11. The following report of the meeting comes from the Society's official delegate, Prof. William H. Chorlton, M. Am. Soc. C.E., professor of structural engineering at the University of Pennsylvania.

Subjects of the six sessions were as follows: Winning the War, the World Crisis, a United Effort, the World We Desire, the Peace to Come, and the Future. Some of the notable speakers on the program were the Mexican Ambassador at Washington, the Russian Ambassador at Washington, the Minister from the Netherlands at Washington, and the Deputy-Premier of the Czechoslovak Government in London.

The Russian Ambassador, Maxim Litvinoff, stated that the following axioms are necessary to the winning of the war:

1. Victory is impossible without the destruction of Hitler.
2. Hitler cannot be destroyed either by blockading Germany or solely by bombarding German towns, but only on the field of battle.
3. The main field of battle lies at present on the territory of the Soviet Union, where the overwhelming majority of the divisions of Germany and of those wrung from her satellites are concentrated and will continue to be concentrated.
4. The Red Army has shown that these divisions can be beaten, driven back, and destroyed.
5. The complete destruction and final defeat of Hitler demands definite united efforts of the Soviet Union and Great Britain, with some supplementary aid from the United States of America.

The chairman of one of the sessions observed that in the war so far the Anglo-Saxon conception of a world order is being best defended by the Chinese and the Russians.

Free Technical Service by Local Sections

THERE IS perhaps a fine distinction to be drawn between what duties engineers may well undertake gratuitously as public services and what ones are of a type requiring payment. For example, Local Sections have been asked to help adjust differences between interested parties, where engineering knowledge and judgment were essential, and have cooperated willingly. Again a Local Section has constituted an "Engineers Committee" to serve permanently in discussions with civic officials.

A different type of problem and solution was involved in a recent experience of the Cleveland Section. It was approached by city authorities for the purpose of securing, on behalf of the municipality, free professional advice. The method by which this request was handled by the Cleveland Section is therefore of general interest.

Because of its deterioration in the course of years, the Central Viaduct over the Cuyahoga River in Cleveland has been in disuse

for three years. The city has been urged to convert it into scrap metal, but has also considered the idea of rehabilitating the structure for pedestrian or vehicular use, the latter to cost possibly $700,000. Accordingly Mayor Lausche asked the Cleveland Section to appoint a committee of three outstanding engineers to study and report on this subject. Presumably the service was to be gratuitous.

In his reply of May 12, 1942, President George E. Barnes of the Local Section reminded the Mayor that the city was fortunate in having a large paid staff of specialists on such problems. To these a special committee would be supplementary. Furthermore,

"In view of its expressed aims, the Society acting as a body or through its committees cannot properly undertake engineering work, and therefore we cannot appoint a committee of the Society for the assignment you offer, but must find some other way in which to help.

"I think you will on reflection agree with us that any authoritative recommendations for a course of action with regard to the Central Viaduct must rest upon individual professional judgment and responsibility. Therefore, we can best serve you by recommending qualified engineers to be engaged by your office under contract conditions which would give them the necessary scope and authority for independent findings. If, therefore, you would care to have us name several engineering consultants any of whom would be unquestionably qualified to serve, either individually or jointly as a properly constituted board, we would be very glad to do so upon request."

Local Sections Conference in Roanoke

Among other noteworthy events at the Spring Meeting of the Society in Roanoke, Va., was the Regional Conference of Local Section representatives on Tuesday, April 21. Sections represented were Alabama, Georgia, Miami, Mid-South, Nashville, North Carolina, Tennessee Valley, Texas, Virginia, and West Virginia. In the absence of W. M. Spann, chairman of the Society's Committee on Local Sections, Prof. J. T. L. McNew, past-chairman and present Contact Member from the Board of Direction, presided over the Conference.

In line with the Society's present policy to lend every assistance toward the war effort, the entire morning session was devoted to the subject of Civilian Protection in War Time. After a brief introduction by Ernest P. Goodrich, chairman of the Society's National Committee on Civilian Protection in War Time, each delegate presented a brief report on the activities of the Local Committee on Civilian Protection in his Section. Following these reports, Mr. Goodrich told of the work being done in other Sections not represented at the Conference, and outlined the type of work expected of the local committees. The Conference provided an excellent opportunity for the exchange of ideas on this subject, which is of great importance today.

At the afternoon session, Secretary Seabury addressed the group on the subject of "Unionization and the Engineering Profession," stating that the Society had recently appointed Howard F. Peckworth, former editor of CIVIL ENGINEERING, to devote his entire time to a study of employment conditions in the civil engineering profession. Again, each Local Section representative was requested to report briefly on activities observed to be going on in his own area toward the organization of engineers into bargaining agency groups.

The latter portion of the afternoon program was devoted to informal discussion of Local Section and Society affairs including "Local Section Records," "Stimulation of Member Interest During the Present Emergency," "Personnel of Local Section and Society Committees," and other topics of interest to Local Sections.

The Conference was well attended by many members of the Board of Direction and other members of the Society who had already arrived in Roanoke for the Spring Meeting.

LOCAL SECTIONS CONFERENCE AT ROANOKE, VA., APRIL 21

Left to Right, Back Row: F. P. Turner, R. Messer, H. H. Marsh, H. Stabler, S. B. Morris, J. W. Cunningham, F. W. Rose (Ga. Tech.), Mr. Riegel (Ga. Tech.), A. Cappellari (W. Va. Univ.). *Middle Row:* E. S. Loane, W. A. Spell, L. L. Hidinger, N. W. Dougherty, L. Edwards, C. W. Ogden, J. Focht, A. J. Saville, P. A. Rice, V. T. Boughton, R. L. Schmid, F. H. Fowler, T. R. Agg, W. L. Malcolm, P. M. Wallace, R. B. Wiley, G. H. Maurice, J. E. Jagger. *Seated:* C. W. Okey, E. P. Goodrich, Miss Edith Conklin, W. N. Woodbury, J. T. L. McNew, E. S. Thomas, Lazarus White, G. P. Boomsliter, S. B. Lilly

Student Chapter Conferences Held

Interesting and Varied Programs Presented at Spring Gatherings at Colleges

Regional Student Chapter Conferences, held under the auspices of the Society's Committee on Student Chapters, continue to flourish. There are now fourteen such conferences in which the Chapters in a convenient area take turns acting as host. In many respects the conferences are similar to Society meetings on a small scale. Their planning and management are entirely in the hands of student officers and committees. The seven reports that follow contain many evidences that the students have handled their responsibilities well, and they are to be sincerely congratulated on their good work.

MARYLAND–DISTRICT OF COLUMBIA—APRIL 24

The University of Maryland was host to the Student Chapters of the Maryland and District of Columbia Sections on the occasion of the Seventh Annual Regional Conference. The sixty-two guests—representing Johns Hopkins University, the Catholic University of America, George Washington University, and the University of Maryland—were greeted by Dr. H. C. Byrd, president of the University. An address was then given by Col. Elliott J. Dent, retired army officer, who related many interesting personal experiences while he was serving in different parts of the world. He also discussed the part the engineer must play in helping to win the war. Motion pictures on the making of tanks and the fighting of incendiary bombs concluded the session.

After lunch members had their choice of two field trips—Brighton Dam, a project of the Washington Suburban Sanitary Commission under construction on the Patuxent River near Laurel, Md., or the Washington Airport. Upon their return from the field trips the group was taken through the aeronautical and testing laboratories at the University.

At the banquet in the evening Dean S. S. Steinberg, of the University of Maryland, acted as toastmaster. An address by Dr. A. E. Zucker, of the modern language department of the University, concluded the meeting. Dr. Zucker spoke on "Modern China," giving an interesting comparison of the Chinese and Japanese temperaments. John N. Williams, president of the University of Maryland Chapter, was in charge of arrangements and presided at the various sessions.

MID-WESTERN CONFERENCE—MAY 1–2

Eight colleges in the Middle West sent delegates to the First Annual Mid-Western Regional Conference of Student Chapters, which took place at the University of Wisconsin on May 1 and 2. The conference was opened by Willard M. Warzyn, of the University of Wisconsin, who was in charge of making all arrangements for the two-day program, and then turned over to Elwyn H. King, president of the conference. F. Ellis Johnson, dean of the engineering college, welcomed the group to the University. Daniel W. Mead, Past-President and Honorary Member, then spoke briefly, as did Dr. Edgar End, of the Marquette University Medical School. The latter's subject was "The Physiological Problems of High Pressure Work," his talk including a discussion of compressed air illness and current research in that field.

Friday afternoon there was a two-hour session on aerial bombardment protection. Those taking part in the symposium were Prof. R. J. Roark, of the University of Wisconsin; G. S. Kessler, of the Wisconsin Industrial Commission; and John Messmer, construction superintendent of Milwaukee County. The program at the banquet that evening provided a contrast to the technical sessions of the day. Toastmaster Alfred Ingersoll added to the hilarity of the evening with his humorous introductions, while Wallace Huber, of the University of Wisconsin, sang. An interesting and unusual talk on "sound" was given by Pat Norris, guest speaker of the evening, and there was a highly successful dance.

The first part of the Saturday morning program consisted of three movies—"Unfinished Rainbows" by the Aluminum Company of America, and "The Co-Axial Cable" and "Defense and the Telephone" by the Western Electric Company. The technique of welding was then explained by F. C. Archer, of the Lincoln Electric Company, and the Conference closed with a display of the thesis projects that are being done in the Hydraulic Laboratory by the University of Wisconsin seniors.

METROPOLITAN CONFERENCE—APRIL 16

ON April 16 Columbia University was host to 133 Student Chapter members in the Metropolitan Area. In addition to Columbia, the Chapters represented were Cooper Union, Newark College of Engineering, New York University, Manhattan College, College of the City of New York, and the Polytechnic Institute of Brooklyn. In an address of welcome J. K. Finch, Renwick Professor of Civil Engineering at Columbia, told the delegates that the war is a challenge to engineers and a great responsibility.

The feature of the occasion was a talk on the "Design and Construction of Commercial Airports," given by Vincent S. Fox, airport

GROUP ATTENDING FIRST ANNUAL MID-WESTERN CONFERENCE OF STUDENT CHAPTERS

engineer for Pan-American Airways. Mr. Fox emphasized the fact that standardization in the design of airports is impossible, as each field presents individual problems. Factors to be considered in design are safe operation, functional layout, and economy. Obstructions in the surrounding country must also be taken into account, and runways in all directions on the least acreage are necessary. Mr. Fox's remarks proved highly interesting and instructive.

Another timely talk was that by William Allen Rose, who gave an illustrated lecture on bomb shelters. Mr. Rose went into his subject thoroughly, covering the different types of domestic and public shelters and discussing danger from blast, fragmentation, debris, anti-aircraft shells, fire, and gas. He is assistant professor of structural engineering at New York University. A tour of the various laboratories on the Columbia campus concluded the conference.

MID-CONTINENT—APRIL 9–11

The second annual meeting of the Mid-Continent Conference of Student Chapters was held at Manhattan, Kans., April 9–11, the Kansas State College acting as host Chapter. Thursday afternoon was spent registering the guests, who were welcomed by L. E. Conrad, acting dean of the engineering school at Kansas State. Delegates were present from the University of Missouri, the University of Kansas, and Kansas State College. In the evening the group were guests of the Kansas State chapter of the American Road Builders' Association for a smoker. Friday morning was devoted to a round-table discussion of Student Chapter problems and activities. Following an informal luncheon, the group visited Camp Funston, where they inspected the sewage treatment plant, pumping station, a typical barracks, and other features of interest to engineers. The Ninth Engineers' Regiment also displayed a part of the equipment used by army engineers.

Friday evening the delegates enjoyed a joint dinner meeting with the Kansas Section of the Society. J. B. Spiegel, president of the Kansas Section, was master of ceremonies, and E. B. Black, President of the Society, was the principal speaker. Mr. Black discussed present membership trends and outlined the role of the Society in the emergency. The general business session on Saturday morning included the election of officers for the third Mid-Continent Conference. These are Van Kieth Anderson, president; June Danzer, vice-president; and Ted Moser, secretary-treasurer.

PHILADELPHIA–LEHIGH VALLEY CONFERENCE—APRIL 19–20

Bucknell University acted as host to the Student Chapters of the Philadelphia and Lehigh Valley Sections on the occasion of the Eighth Annual Conference, which took place on April 20. For the convenience of those coming from a distance the Bucknell Chapter had arranged a smoker and general get-together meeting for the preceding Sunday evening, providing the guests with lodging for the night. The principal speaker was Commander J. R. Perry, C.E.C., U.S. Navy, who discussed "The Organization and Work of the U.S. Naval Construction Regiments."

Presentation of technical papers, in the annual student contest, was also a feature of the Monday program. First prize, consisting of $20 in cash and $20 for entrance fee and dues as a Junior in the Society, went to Louis M. Laushey, of Pennsylvania State College, for his paper on "Model Studies of an Ogee-Type Spillway"; second prize of $20 for entrance fee and Society dues to Joseph C. Whiteman, of the University of Delaware, for a paper on "The Erection of the Main Span of the New St. Georges Bridge"; and third prize of $10 for entrance fee or Society dues to Ervin Spindel, of the Drexel Institute of Technology, for a paper on "Protection of Roads at TVA Reservoir Crossing."

The president of the Philadelphia Section, Charles A. Howland, was present and spoke briefly. Other talks were given by E. L. Durkee, representing the Lehigh Valley Section, and Howard K. Preston, chairman of the Philadelphia Section's Committee on Student Chapters. Climaxing three years of publication, the host Chapter's newspaper, "On the Level," was presented in the form of a convention issue, with notes of welcome from and bits of information concerning Bucknell professors and students, as well as general Student Chapter news.

VIEW OF GROUP ATTENDING STUDENT CHAPTER CONFERENCE AT BUCKNELL

NORTHERN NEW YORK CONFERENCE—APRIL 25

The Sixth Annual Northern New York Conference of Student Chapters took place at Syracuse University on April 25, with delegates present from Cornell University, Clarkson College, and Syracuse University. A tour of the buildings and laboratories on the campus initiated the program. Then Prof. E. F. Berry, head of the civil engineering department at Syracuse University, gave an illustrated lecture on "The Romance of the Bridge." A luncheon featuring steak was served at noon, after which Dean Louis Mitchell spoke on the role of the engineering student in the war. The guest speaker was Prof. W. J. Hansen, of the Syracuse college of law, who discussed the relationship of law to the engineer.

At the afternoon session the heads of the various student Chapters spoke, and there was a general discussion as to the advisability of holding the conference during the war. The annual student paper contest concluded the program, first prize going to Clyde Johnson for his paper on city planning problems, and second to David Shub for a paper on "The History of Roads."

ROCKY MOUNTAIN CONFERENCE—APRIL 18

Over one hundred delegates—from the University of Wyoming, the University of Colorado, and Colorado State College—were in attendance at the Third Annual Rocky Mountain Conference, held at Colorado State College on April 18. During the morning delegates and faculty visited the newly enlarged college airport and the site of the proposed Horsetooth Reservoir, a part of the Colorado-Big Thompson Diversion Project. The various phases of the project were explained by Ralph Parshall, senior irrigation engineer for the U.S. Department of Agriculture.

At noon there was a luncheon, with Milton Moreland acting as toastmaster. Dean N. A. Christensen, of the engineering department at Colorado State, welcomed the guests, and Wilmer McMillin, assistant to the president of the college, was the speaker. Following the luncheon the official delegates held a business meeting, and the remainder of the guests visited the hydraulics laboratory at the college. The following officers were elected for the 1942 conference: Walter Colwell, president; Roy Suton, vice-president; and David Flemming, secretary-treasurer.

SPRING MEETING CONFERENCE—APRIL 22–23

On April 22 and 23 the Virginia Military Institute Chapter was host to a Conference of Student Chapters held in Roanoke in conjunction with the Spring Meeting of the Society. The meeting was called to order Wednesday afternoon by Cadet Jack Hughes, president of the V.M.I. Chapter, who introduced Cadet W. F. Cline, president of the V.P.I. Chapter. F. P. Turner, principal assistant engineer of the Norfolk and Western Railway and Contact Member for the V.P.I. Chapter, then welcomed the guests on behalf of the city of Roanoke and the Virginia Section. Mr. Turner pointed out the advantages of membership in the Society and discussed the Code of Ethics. He was followed by Charles B. Burdick, Vice-President of the Society, who discussed the qualities that go to make a "good engineer."

Other speakers heard during the day included Comdr. John S. Leister, C.E.C., U.S. Navy; James E. Jagger, Field Secretary of the Society; Daniel W. Mead, Past-President and Honorary Member of the Society; Brig. Gen. James A. Anderson, highway commissioner for the state of Virginia; and E. M. Hastings, chief engineer of the Richmond, Fredericksburg and Potomac Railroad. Mr. Hastings, who is chairman of the Society's Committee on Student Chapters, gave a timely and inspiring talk that elicited much enthusiasm. "We need to be optimistic enough to know that the future holds for us and for our nation high, fine, and noble things, only as you and I fit ourselves to perform the task that is here for us to perform for the welfare of mankind," he pointed out.

There was a dinner-dance Wednesday evening, the V.M.I. orchestra, the "Commanders," supplying the music. The address of the evening was given by David C. Prince, president of the American Institute of Electrical Engineers and vice-president of General Electric. Mr. Prince's subject was "Post-War Planning." On Thursday the V.M.I. Chapter was host to a group of members and lady guests attending the Spring Meeting. An account of the occasion appears in "Student Chapter Notes" in this issue.

Guests were present from ten colleges, and the delegation from the A. and M. College of Texas received the Virginia Section's cash prize of $20—offered to the Chapter whose delegates traveled the greatest number of "man miles" to attend the Spring Meeting.

Revision of Definitions of Terms Used in Sewerage and Sewage Disposal Practice

STEPS are being taken looking toward the modification of the standard definitions of terms used in sewerage and sewage disposal practice, according to the report of W. W. Horner, chairman of the committee for this purpose. His report, a statement of progress, was made to the Sanitary Engineering Division, one of the sponsors of the effort, at the Division's annual meeting in New York in January.

These definitions were originally published in Manual No. 2 of Engineering Practice, which is now out of print. A review of the old manual made it evident that many of the original definitions are no longer valid, and that many new terms have come into sanitary engineering practice that should be included in a list of this kind.

In response to the need of the profession for a revised up-to-date list of such definitions, the Executive Committee of the Sanitary Engineering Division authorized a new committee to consider this matter. In May 1941 a committee of the Sanitary Engineering Division was set up with Mr. Horner as chairman. After correspondence with other interested organizations, and after review of work which had previously been done under the leadership of Langdon Pearse, the effort was expanded and transferred to a joint committee under the general chairmanship of Mr. Horner. The committee was constituted as follows:

W. W. Horner Langdon Pearse E. Sherman Chase	representing the American Society of Civil Engineers
F. W. Jones C. E. Keefer C. J. Velz	representing the Federation of Sewage Works Associations
Paul Hansen Gordon M. Fair H. A. Whittaker	representing the American Public Health Association

All these men except Messrs. Jones and Whittaker are Members of the Society.

It was agreed that Mr. Pearse would complete the initial revision of the definitions, and that the results of his work would constitute a first draft for the committee's consideration. Mr. Pearse completed the preparation of a revised list which was issued to the full committee on November 10, 1941, and the terms contained in this list and the definitions for them have been under discussion within the committee since that time. The work of completing the revision is proceeding satisfactorily but somewhat slowly because of the preoccupation of many of the members with national defense matters. Chairman Horner advises that the committee expects to complete its revision work during the current year, and to be able to present the revised list to the Sanitary Engineering Division at the time of the next Annual Meeting. It is expected that this list will be published as a revision of Manual No. 2, but it may also be published and distributed separately by the collaborating organizations.

To Increase Society Membership

AT ITS Roanoke meeting, the Board of Direction approved the studies and recommendations of its Committee on New Members, which are here summarized. The Committee reported that in a present total of more than 17,700 Society members, 71.9% represented Corporate Membership and 27.5% represented Junior membership. Growth among the younger men has been consistently vigorous, so that the concern of the Committee was particularly to foster a similar growth of Corporate Membership.

Accordingly the Committee advised that special efforts be made to increase the number of Corporate Members, with the feeling that the standing and effectiveness of the Society tends to be affected by such healthy growth, not only locally but in broader, country-wide activities. Hence the Committee's recommendation, as approved by the Board, was to the effect that:

1. Each Local Section should accept the obligation of appointing a "Local Committee on New Members."

2. These committees should be composed of men prominent in local engineering affairs; they should have a wide acquaintance in the profession, and in all ways be fitted to judge the qualifications of prospective candidates for Society membership.

3. Emphasis is to be placed on the thought that the aim of the committee of the Section should not be merely to add to the Society's membership but to gather into the Society such men as have attained some distinction in the engineering profession.

4. The manner of approach is important, and the contact should be made by a member of the Society who is acquainted with the prospective candidate, or by one whom the prospective candidate will be likely to hold in respect.

5. An invitation to join the Society should be made only after study and review by the committee on the qualifications, character, and personality of the prospect; this information should also be discussed with the Local Membership Committee to insure that no adverse action is likely to be taken by it after an invitation has been extended and accepted.

6. In making an approach, mention should be made of the mutual advantage that will accrue to the prospective member and to the Society, such as receipt by the member of the Society's publications, the opportunity to participate in discussions of interesting technical subjects and for fellowship in the profession through attendance at Society and Local Section meetings. From the point of view of the Society, there is the obligation of members of the profession to participate in Society work through committees, through the activities and interests of the Local Sections, and by the presentation and discussion of papers. There is also the obligation to assist in extending the influence of the Society in national and local affairs, and in generally enhancing the status of the engineering profession.

These procedures have been found effective in practice. The Board Committee feels that similar excellent results will accrue from the general adoption of this plan.

The Engineering Foundation Issues Annual Report

THE 1940–1941 Annual Report of the Engineering Foundation, recently issued, lists thirteen projects, comprising thirty-four separate problems, on which work has progressed. A summary of the year's researches in which Society Committees are cooperating is included in the Report. It outlines Project 38 of the Soil Mechanics and Foundations Division and Project 67 of the Special Committee on Hydraulic Researches.

The Foundation's policy of making relatively small appropriations to a considerable number of projects in diverse fields of engineering was continued. In all cases these projects had the approval of one or more of the Founder Societies, and in most cases they had additional support from those societies or from industry. The Foundation has thus been able to promote research to a greater extent than would be possible if only the direct support of the Foundation were involved.

On September 30, 1941, the Foundation completed its twenty-seventh fiscal year, having been established in 1914.

New Boston Office for the Personnel Service

IT HAS BEEN found necessary, and feasible, to expand the work of the Engineering Societies Personnel Service. Effective June 1 a new office is being opened, to serve a large New England territory. Space has been taken at 4 Park Street, Boston, Mass., and George W. Gilmore has been appointed manager.

This office will carry on the work of the Emergency Planning and Research Bureau, Inc., of Boston with which Mr. Gilmore has been associated for some time. He therefore is familiar not only with the field but with the machinery that has already been working there to serve technical men.

This new office is the fifth branch of the Engineering Societies Personnel Service, Inc. The other four are in New York City, Detroit, Chicago, and San Francisco.

Don P. Reynolds Joins Editorial Staff

THE SOCIETY IS privileged to welcome one of its promising younger members into the full-time work of the organization. Don Potter Reynolds of Toledo, Ohio, began work as assistant editor of CIVIL ENGINEERING in the middle of May. His acceptance of this work again completes the organization as depleted through the transfer of Howard F. Peckworth to other duties.

DON POTTER REYNOLDS

Although not extensive in terms of years, Mr. Reynolds' experience has been valuable in its variety. His training was at the University of Michigan, where he took his bachelor's degree in 1938 and his master's degree in civil engineering later the same year. In college, he served on the staff of the *Michigan Technic* as business manager. His special field, in college and since, has been structural engineering.

His early professional work was with the State of Michigan on bridge and road construction in its highway department. A later activity was in the employ of the City of Toledo, as assistant to the director of public service, on investigations and reports dealing with the coordination of construction activities. Still later he was engineering aid on the construction of the new Lake Erie Water Supply System for that city. Going back to structural work, he served for over two years as designer with the Sun Oil Company. For the last few months he has been engaged on structural problems as engineer in the office of the consulting firm of Mills, Rhines, Bellman, Nordhoff, of Toledo, Ohio. All this later work has been in and around Toledo, where he has made his home.

In the Toledo Section of the Society, Mr. Reynolds has been active as junior assistant to the president. He has also been a member of the Section's committee on new members. Last January, at the Society's Annual Meeting, he was recipient of the first award of the Mead Prize for Juniors.

To his new work for the Society, Mr. Reynolds brings many of the better qualities of the young engineer. He has the enthusiasm, the confidence, and the idealism that give him a fine background. It is hoped that many members of the Society will in the course of time come to know him and to enjoy at first hand his friendly helpfulness. Already he and Mrs. Reynolds and their two young children have settled permanently at Colonial Heights in suburban Tuckahoe, N.Y.

Concrete Specifications in Spanish

RECENTLY there has been published a Spanish translation of the Joint Committee Report on "Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete." The new printing, particularly for use in the Argentine, has been sponsored by the Instituto del Cemento Portland Argentino in Buenos Aires, Republic of Argentine.

The complete Joint Committee report is included, appendices and all. A copy of the translation in cardboard covers and another in cloth binding have been donated to the Society. This Spanish edition may be consulted in the Engineering Societies Library at Headquarters. The Instituto del Cemento Portland Argentino is to be congratulated on this progressive step in making available the most up-to-date material on this subject to all Spanish speaking people.

Since its original publication in June 1940, the Joint Committee Report has received increasing attention. As far as is known, the present translation into Spanish is the first of that nature. A special edition of the report was printed and bound for the use of Society members and is available upon request to Headquarters. The price is $1.50 a copy, from which there is a 50% discount to members in any grade.

Appointments of Society Representatives

LANGDON PEARSE, M. Am. Soc. C.E., has been appointed one of the Society's representatives on the Board of the Washington Award to fill the vacancy caused by the resignation of SAMUEL A. GREELEY, M. Am. Soc. C.E. His term will expire in May 1943.

J. P. H. PERRY, M. Am. Soc. C.E., has been reappointed one of the Society's representatives on the Board of Trustees of United Engineering Trustees, Inc., for the three-year term, October 1942–October 1945.

GEORGE E. STREHAN, M. Am. Soc. C.E., has accepted an appointment to represent the Society on the American Standards Association Committee A51 on Building Code Requirements for Fire Protection and Fire Resistance.

News of Local Sections

Scheduled Meetings

MIAMI SECTION—Dinner meeting at the Seven Seas Restaurant on June 4, at 7 p.m.

NASHVILLE SECTION—Dinner meeting at Kissam Hall, Vanderbilt University, on June 2, at 6:15 p.m.

NEBRASKA SECTION—Dinner meeting at the Hill Hotel on June 3, at 6:45 p.m.

PHILADELPHIA SECTION—Dinner meeting at the Engineers' Club on June 9, at 6 p.m.

SAN FRANCISCO SECTION—Dinner meeting at the Engineers' Club of San Francisco on June 16, at 5:30 p.m.

SPOKANE SECTION—Luncheon meeting at the Davenport Hotel on June 11, at 12 m.

TEXAS SECTION—Luncheon meeting of the Dallas Branch at the Dallas Athletic Club on June 1, at 12:10 p.m.

Recent Activities

BUFFALO SECTION

A talk on "Traffic Control and Safety, and the War" was the feature of the luncheon meeting held on April 22. This was given by Henry W. Osborne, new traffic engineer for the city of Buffalo. By way of introducing the subject of traffic safety, Mr. Osborne stated that there were 40,000 fatalities in traffic accidents last year, and over a million persons injured. To solve the problem locally, the city has now prepared a plan for a war-transport system to utilize the arterial highways in the city with primary, secondary, and alternate routes. Studies have also been made of bottlenecks at intersections, and several plans for the re-design of particularly bad intersections in the city have been drawn up. Parking surveys made in congested Buffalo areas indicate that a large number of parking violations add to the traffic problem.

CINCINNATI SECTION

At the annual meeting of the Cincinnati Section, which was held on March 31, Robert C. Sale, president of the University of Cincinnati Student Chapter, was awarded the Section's prize of $10 for entrance fees into the Society. A talk on "The Location and Early Growth of Cincinnati," was then given by Prof. James A. Quinn, of the department of sociology at the University of Cincinnati. Professor Quinn's talk revealed interesting data on early floods and on the topography of the first settlements. At the conclusion of the meeting the following new officers were installed for the coming year: Joseph C. Bussey, president; Raymond W. Renn, vice-president; and Warren W. Parks, secretary-treasurer.

DISTRICT OF COLUMBIA SECTION

The District of Columbia Section made its annual award to outstanding seniors from the local Student Chapters at a dinner meeting on April 28. Awards of Junior membership in the Society were made to Louis Cattaneo, of the Catholic University of America, for a paper on "Timber Construction," and to Walter Douglas, of George Washington University, for a paper entitled "Planning a Gas Transmission Line from Washington to Alexandria." A short report on the Society's Spring Meeting at Roanoke was presented by G. L. Parker, and two short motion pictures on war subjects concluded the program.

GEORGIA SECTION

On April 13 Frank K. Shaw addressed a dinner meeting of the Georgia Section on the subject of the new Bell Aircraft Bombing Plant being built near Atlanta. Mr. Shaw, who is industrial secretary of the Atlanta Chamber of Commerce, stated that one room alone had an area of 3 million square feet, and that the employees' payroll is approximately half the total payroll of the city of Atlanta.

The May meeting was a joint session with the Student Chapter at the Georgia School of Technology. Announcement was made of the award of the Georgia Section's prizes of Junior membership in the Society, first prize going to C. L. Peacock and second to Hugo Quillian. The William A. Hansell prize, given by Mr. Hansell and consisting of Junior membership in the Society and a pin, was presented to J. T. Bell, Jr. Later F. W. Rose and J. A. Feagle, also Student Chapter members, reported on the Spring Meeting. The feature of the occasion was a talk on "Rainfall, Runoff, and Soil Loss on Georgia Farms," given by John R. Carreker, associate agricultural engineer of the Southern Piedmont Experiment Station at Watkinsville, Ga. Mr. Carreker illustrated his talk with charts of typical winter and summer storms, which showed the startling improvement obtained in the erosion situation by rotating row crops such as corn and cotton with cover crops such as grain and lespedeza. Of purely engineering interest was the evidence that the runoff rate almost equalled the rainfall rate from small test plots once the initial detention had taken place.

INDIANA SECTION

The annual joint banquet of the Indiana Section and the Student Chapters at Purdue University and Rose Polytechnic Institute took place at Purdue on April 16. The speaker of the evening was George T. Seabury, Secretary of the Society. Mr. Seabury discussed the rôle of the engineer in the present emergency, pointing out that this is an engineers' war and that approximately thirty persons behind the lines are engaged in war effort to one in the combat lines and that a goodly number of these thirty are technically trained persons. In closing, he exhorted all engineers, and especially those who are just graduating, to give their very best to the war effort. A brief talk by Prof. R. B. Wiley, head of the civil engineering school at Purdue and Director of the Society, concluded the technical program.

IOWA SECTION

In April the Iowa Section enjoyed joint meetings with two Student Chapters—with Iowa State College on April 8 and with the University of Iowa on the 13th. Members of the Iowa City Engineers' Club were also present on the latter occasion. At the first of these meetings Anson Marston, Past-President and Honorary Member of the Society, discussed the engineer's responsibility in the war. Added interest was given the meeting because it celebrated Dean Marston's fiftieth year at Iowa State College. The speaker at the Iowa City meeting was R. A. Caughey, professor of structural engineering at Iowa State College, who gave an illustrated lecture on "Aerial Bombardment Protection."

ITHACA SECTION

On April 17 the Ithaca Section was one of seven technical groups participating in the Fourth Annual Joint Meeting of the Technical Societies of the Southern Tier. This gathering, which was held at Binghamton, N.Y., attracted a large attendance. The program included a talk on "Conversion to War Production," which was given by C. A. Woodruff, chief of the Conversion Unit of the War Production Board. Later in the month, 22 senior class members of the Cornell University Student Chapter were dinner guests of the Section. In a brief address of welcome S. C. Hollister, dean of the college of engineering at Cornell, explained the advantages of affiliating with the Society as soon after graduation as possible. The guest speaker was Charles E. Smith, vice-president of the New York, New Haven and Hartford Railroad, who addressed the

group on the topic of "Railroad Transportation in the Present Emergency."

LOS ANGELES SECTION

An interesting program had been arranged for the April meeting of the Section. First, Larry Reuland, of the B. F. Goodrich Company, spoke on the development of synthetic rubber, illustrating his talk with chemical demonstrations and with motion pictures of the process of manufacture. He was followed by John Quincy Adams, licensed guide for the Alaskan Game Commission, who discussed "Game and Glaciers." In connection with his talk Mr. Adams showed motion pictures of animal life in Alaska and of Lake George. In the spring the outlet to this lake is obstructed by a glacier, and the water often reaches a depth of 1,000 ft. In the summer, however, the lake is practically drained when it overtops and breaks the barrier, discharging its entire volume of water in a period of a week or ten days.

MARYLAND SECTION

On April 9 members of the Maryland Section motored to Washington, where they were guests of the District of Columbia Section. Brief talks were given by Alonzo J. Hammond and Frederick H. Fowler, Past-Presidents of the Society; Gustav J. Requardt, Director of the Society; and Hal H. Hale, assistant to the Secretary and the Society's Washington representative. The principal speaker was Dr. G. Wilson Shaffer, professor of psychology and dean of the college of arts and sciences at Johns Hopkins University, whose subject was "The Psychology of Humor."

METROPOLITAN SECTION

"Precautions to Be Observed in the Use of Materials in Subaqueous Harbor Construction" was the topic of discussion at the April meeting of the Metropolitan Section. Those taking part in the symposium were Dr. William F. Clapp, who described the various marine organisms that attack timber structures; Gerald G. Greulich, member of the Society's Committee on Bearing Value of Pile Foundations, who discussed the precautions to be observed in the use of steel; and J. A. Mullin, of the Raymond Concrete Pile Company, who considered the subject of precautions to be observed in the use of concrete. A general discussion of these problems followed.

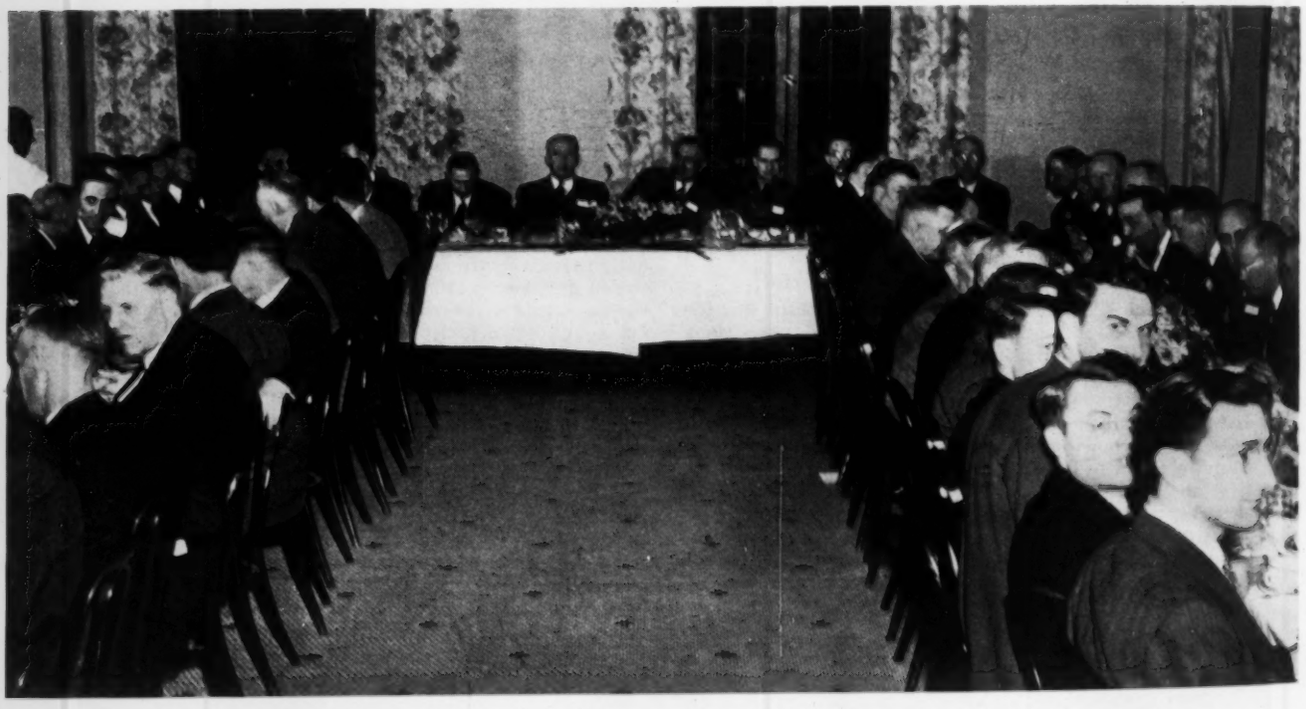
MICHIGAN SECTION

A joint meeting of the Section and the Toledo Section took place in Detroit on February 4. A talk on the new Lake Erie water supply for Toledo comprised the technical program. This was given by George N. Schoonmaker, city manager of Toledo, who also showed motion pictures of construction work on the project.

In April the Section participated in a large joint meeting that had for its theme "Wartime Construction." The other sponsoring bodies were local groups of the American Institute of Architects, the Army and Navy, the Associated General Contractors of America, and the Producers' Council, the latter group acting as host. All the talks stressed the conservation of critical materials. Chauncey M. Goodrich, representing the Michigan Section, discussed methods that could be used to conserve steel. To accomplish this end, Mr. Goodrich advocated the use of higher working stresses, at least for structures of a temporary nature.

TENNESSEE VALLEY SECTION

A number of business matters were discussed at the April 14 meeting of the Chattanooga Sub-Section. A talk on "The Effect of War on the Tennessee Highway Department"—given by J. W. Gentry, state highway engineer—comprised the technical program. An animated discussion followed his talk.



MEMBERS AND GUESTS OF WEST VIRGINIA SECTION AT SPRING DINNER MEETING

WEST VIRGINIA SECTION

Members of the Charleston Chapter of the West Virginia Society of Professional Engineers were guests of the West Virginia Section on April 3. Members of the Section and their guests met at the Kanawha Hotel in Charleston for dinner and a technical session. The after-dinner speakers were R. P. Davis, dean of the college of engineering at West Virginia University, whose subject was "Emergency Education in Wartime," and J. W. Carter, president of the Student Chapter at the University, who discussed bomb protection. Later in the evening Field Secretary Jagger spoke on Society affairs, and Lt. Col. F. H. Falkner, district engineer for the U.S. Engineer Office at Huntington, W.Va., gave a talk on Bluestone Dam. A film entitled "From Mountain Top to Mountain Top"—prepared by the West Virginia Road Commission—concluded the program. This film, which shows the part played by West Virginia industry in the war, was much appreciated.

On Saturday morning, April 4, the group enjoyed an automobile ride through the industrial section of Charleston, the trip culminating in a visit to the plant of the Libbey-Owens Glass Company.

NORTHEASTERN SECTION

Recent meetings of the Junior Association of the Northeastern Section have stressed talks by members of the Association. At the session held on March 23 Paul C. Grueter, associate engineer for the U.S. Engineer Department at Boston, Mass., discussed "Model Studies of the Cape Cod Canal." At the April meeting Norman Cleveland spoke on "Long Pile Foundation Construction." Mr. Cleveland, who is structural engineer for Jackson and Moreland, of Boston, illustrated his talk with lantern slides and colored motion pictures. The second speaker on the program was Harold A. Thomas, instructor in sanitary engineering at Harvard University, whose subject was "Model Studies of Flow in a Network of Pipes." Mr. Thomas illustrated his talk by means of a small demonstration model, and the members later visited the hydraulic laboratory to view the actual model upon which studies are made.

PHILADELPHIA SECTION

On April 9 members of the Section went to Trenton, N.J., where they had a joint meeting with the Engineers' Club of Trenton. An inspection tour of the grounds at Fort Dix had been arranged for the afternoon, and despite a heavy rainstorm about sixty turned out to inspect the various plants and buildings in this vast project. Through the courtesy of Maj. W. H. Byington, area engineer, a number of engineer officers acted as guides and explained the points of special interest to engineers. Later there was a dinner at the Stacy Trent, followed by the joint session with the Engineers' Club. There were almost 500 present for the technical program, which included talks by Lt. H. C. Ballou, of the Naval Aviation Cadet Selection Board, New York City, who discussed the courses for pilots being inaugurated in various colleges, and Capt. H. Wheeler, of the U.S. Army Air Corps at Fort Dix, who spoke on "Air Reconnaissance and Observation."

SACRAMENTO SECTION

The Sacramento Section continues its custom of having weekly luncheon meetings. The list of speakers appearing at recent sessions includes Warren E. De Young, district manager and Western representative of the Automatic Signal Corporation; Maj. Austin C. Mathene, executive officer of the Civilian Defense Division of the Ninth Corps Area; A. W. Copley, San Francisco regional director of the Westinghouse Electric and Manufacturing Company; Fred Lohse, chemical engineer for the Permanente Metals Company at San Jose, Calif.; and Royal E. Fowle, engineer and production manager for the Granite Rock Company at Watsonville, Calif. On one occasion there was round-table discussion on registration of civil engineers, the event marking the twentieth anniversary of the founding of the State Board of Registration for Civil Engineers; on another, Fred Sprague presented a double-feature motion picture—"Let's Go Fishing" and "Traveling Through Oregon."

SAN DIEGO SECTION

An illustrated lecture on "Investigations of Shoreline Erosion at La Jolla, Calif.," comprised the technical program at the March meeting of the Section. The speaker was Dr. Francis T. Shepard, of the Scripps Institute of Oceanography. On April 23 the members of the Section met for dinner and an inspection tour of the Tavares Concrete Ship Construction Plant at National City, Calif. The tour covered construction of the dry dock, the building of the forms, and an inspection of the concrete mix.

SAN FRANCISCO SECTION

There was a large turn-out for the regular bi-monthly meeting of the San Francisco Section, which took place on April 21. The technical program consisted of an illustrated talk on "Wartime Bridge Construction Problems," given by Fred W. Panhorst, bridge engineer for the California State Division of Highways. Mr. Panhorst described some of the devices developed by his department for building adequate bridges with a minimum use of critical war materials. He pointed out that in the present design of structures consideration is being given to the possibility of later conversion into standard types of permanent bridges when unlimited use of materials is again permitted.

Student Chapter Notes

GEORGIA SCHOOL OF TECHNOLOGY

The Student Chapter at the Georgia School of Technology reports that twenty-two of its graduating members are entering the armed service of the country—five each going to the Engineer Corps of the Army, to the Navy, to the Ordnance Department, and to the Signal Corps, and two to the Coast Guard. All will be commissioned officers and will have an important opportunity to utilize their engineering training.

During the past months several field trips have been made to engineering work in progress in and around Atlanta. The members have thus had an opportunity to study the use of soil cement in airport construction, the operation of a water-purification plant, and the manufacture of concrete pipe. The list of speakers heard at the regular meetings includes Maj. A. O. Taylor, of the U.S. Engineer Corps, and James E. Jagger, Field Secretary of the Society. The latter discussed the aims and activities of the Society.

NEWARK COLLEGE OF ENGINEERING

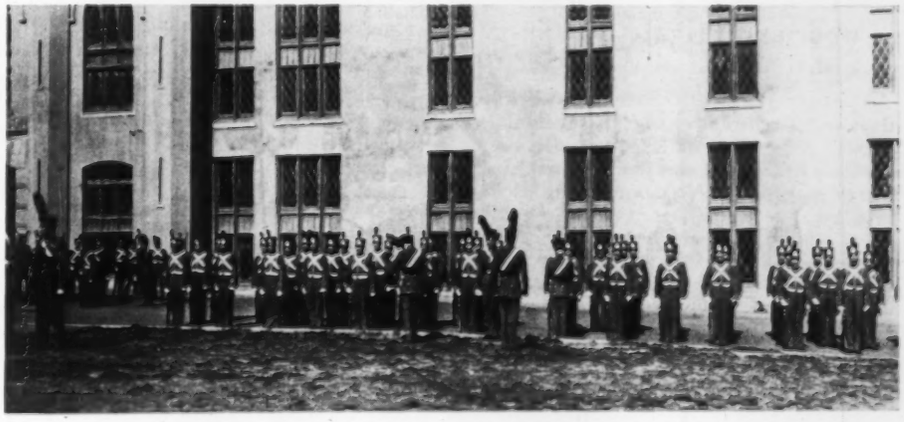
At the April meeting of the Newark College of Engineering Student Chapter, Harold E. Wessman, professor of structural engineering at New York University, spoke on "Civil Engineering Responsibilities in Air Raid Protection." Dr. Wessman is chairman of the Metropolitan Section's Committee on Civilian Protection in War Time.

NEW YORK UNIVERSITY

"The Aerial Camera as a War Weapon" was discussed by Walter J. Scholla at a meeting of the New York University Chapter, which was held on April 29. Mr. Scholla is superintendent of public works at Montclair, N.J., and part-time instructor in photogrammetry at the university.

VIRGINIA MILITARY INSTITUTE

At the time of the Society's Spring Meeting in Roanoke on Thursday afternoon, April 23, the Chapter had the privilege of helping to entertain a special party of Society members, ladies, and guests. The party arrived by bus from Roanoke. After brief talks in Lee Chapel, the visitors were taken on a special tour of the grounds and buildings, concluding with tea in Preston Library, where ladies of the civil engineering faculty of the Institute did the honors. The special treat of the afternoon was the formal cadet review on the parade grounds. At the conclusion of the drill the party left for a picnic supper and evening at Natural Bridge.



CADETS PREPARING FOR THE CEREMONY AT V. M. I.

ITEMS OF INTEREST

About Engineers and Engineering

CIVIL ENGINEERING for July

AS THE ELEMENT of transportation looms ever larger in the defense program, the performance of high-speed trains assumes added importance. How this affects the railroad engineer is explained in the July number by H. B. Christianson, Assoc. M. Am. Soc. C.E., in his paper on "Track Problems in the Operation of Streamliners." He relates the means the roads are taking for handling many of the details connected with this type of transportation. For instance, reduction of curvature to 1° or less is a prime requisite.

A subject that grows daily in importance is that of "Conservation of Critical Materials in Construction," which is discussed by J. H. Ehlers, M. Am. Soc. C.E. He contends that engineers must revise their ideas; where formerly they considered mainly financial economies, now they must put the emphasis on the expenditure of available materials. In this timely paper he explains what this problem involves and how it may be logically approached.

New housing of vast proportions has been erected in many communities throughout the land. Frequently this has been in conjunction with slum clearance. Such was the case with the "Phoenix Low-Cost Housing Development," a 2,000-room project in three areas, described by John Girand, Assoc. M. Am. Soc. C.E. Great pains in design, construction, and inspection were amply rewarded in the securing of what is claimed to be the most economical housing development of its type in the United States.

Conservation of money, labor, and critical material is accomplished by refuse disposal in "Sanitary Land Fills in New York City," as explained by Rolf Eliassen, Assoc. M. Am. Soc. C.E. At first the public was alarmed by this method of disposal and protested, but disinterested study disclosed that land fills not only solved the disposal problem but eliminated other independent nuisances. Ample precautions are taken against fire, odors, vermin, dust, and dangers to health.

Public and Private Building Construction in Wartime

ENGINEERING construction is faced today by an inherent conflict between the urge to get necessary things done and the restriction of materials with which to work. Some suggestions for approaching this problem have been collected from Government officials and are here given. Admittedly, this brief information is incomplete, but it does give some idea of the difficulties and of the measures that may help to solve them.

It is stated by the War Production Board that although the construction industry has been converted almost entirely to military and other essential construction, it is anticipated that the Nation will have the largest building program in its history. In order to complete this program, the volume of construction for the year must reach about $14,750,000,000 as compared to $11,500,000,000 for 1941. This increase, together with the fact that war demands require a much larger proportion of steel, copper, and other metals and alloys than is normally used in construction, has caused a serious shortage of certain materials. For example, while steel-plate production for April will be in excess of 850,000 tons, the demand exceeds the supply by 50% or more.

It is estimated that the shipment of iron ore on the Great Lakes this year must surpass all previous records. Lake producers are being asked to supply the steel makers with almost 90,000,000 tons during the 1942 season. In order to alleviate to some extent the shortage of certain materials, the War Production Board is demanding the substitution of less critical products and the construction of temporary facilities.

Since the attack on Pearl Harbor, the War Public Works of the Federal Works Agency has had to revise its policy. While it is continuing to provide needed facilities, it has had to eliminate the construction of permanent buildings to a great extent, and substitute so-called temporary construction, in order to conserve those vital materials which are so urgently needed by the armed forces.

It is true that there are some circumstances under which it is not advisable or practical to construct temporary buildings. For example, in some instances a regular addition to a school or a hospital in a defense area would require less critical materials than it would to provide the facilities in the form of a temporary building.

Intensive study of substitute materials in war public works construction has been under way for some time by Government agencies. Use of wood stave pipe and concrete pipe in place of steel and cast iron for water mains, the use of non-reinforced concrete pipe and vitrified clay pipe for all sewers, and the substitution of timber for all structural steel are among the steps being taken wherever feasible in conserving the use of critical materials. While there is no definite list of substitutes, the War Public Works is endeavoring to make the substitutions listed in Table I wherever feasible.

In the heavy construction field, larger columns may have to be used to compensate for the absence of reinforcing steel; brick or timber or reinforced concrete beams can take the place of solid steel; siding and roofing can be made of several substitutes with lightly reinforced slabs

TABLE I. SUGGESTED SUBSTITUTIONS IN GENERAL CONSTRUCTION

ITEM	FORMERLY SPECIFIED	SUGGESTED SUBSTITUTIONS
Frame	Structural steel	Wood frame
Roofing	Metal	Membrane, composition shingles, wood shingles or slate
Flashings	Copper or galvanized metal	Membrane or bonderized metal
Leaders and gutters	Copper or galvanized iron	Bonderized metal
Roof trusses, struts, and purlins	Steel	Wood
Anchors, straps, bolts, ties, and hangers	Galvanized or cadmium plated	Asphalt-coated steel
Stair frames	Steel frames	Wood
Stair (railings)	Wrought iron	Wood
Windows	Steel and Kalamein	Wood
Lintels	Steel	Stone or wood
Doors	Hollow metal	Wood except for fire doors which shall be of Kalamein
Door bucks	Steel	Wood except where required for fire doors, where Kalamein will be used
Ornamental metal	Iron, bronze	Eliminate
Hardware	Bronze and brass	Ferrous metals except exterior doors
Partitions	Steel	Masonry, marble, or slate
Lockers and cabinets	Steel	Wood
Lightning conductors	Copper	Eliminate
Insulation	Cork	Rock wool
Skylights	Copper	Galvanized iron or bonderized metal
Screens	Aluminum or bronze	Galvanized cloth, wood frames
Weatherstripping	Zinc or bronze	Felt
Thresholds	Bronze	Wood or cast iron
Lath	Wire and expanded metal	Wood or gypsum
Elevator cabs	Steel	Wood
Kick plates	Bronze	Eliminate
Manhole covers	Cast iron	Cast iron for roads
Flooring	Rubber	Eliminate
Flooring	Cork	Eliminate
Boilers (up to 7,500 sq ft)	Steel	Cast iron
Radiators	Copper	Ferrous
Unit heaters	Copper	Ferrous
Unit ventilators	Copper	Ferrous, but eliminate where possible
Oil burners	.....	Avoid where possible
Stokers	.....	Avoid where possible
Gas conversion burners	.....	Avoid where possible
Pipe and fittings, steam or water	Copper and copper-base alloys	Iron or steel
Air ducts and fittings	Galvanized metal, tin, or copper	All black iron or composition risers with galvanized fittings
Valves	Copper or copper-base alloys	Iron bodies over 1½ in.
Insulation	Asbestos	Rock wool, air cell, or magnesia
Oil storage tanks	Steel	Reinforced concrete where possible

for roofing in special cases. Where fire hazards are acute, timber construction can be made fire-resistant by chemicals.

The War Production Board has stated that its efforts to divert iron and steel into their most essential war applications will not be complete until every possible substitution for uses in civilian activities has been achieved. Additional civilian industries dependent on iron and steel will either be converted to war manufacturing or be forced to close down.

N. G. Neare's Column

Conducted by

R. ROBINSON ROWE, M. AM. SOC. C.E.

"REMEMBER," warned Professor Neare, "the words of the cynic, 'Require seven scholars to reckon the strength of a column, and the seven learned theses will be as profound as the seven wonders of the world—and even so diverse!'

"Tonite I count more than seven hydrokinematists in attendance, attracted, perhaps, by the problem proposed by M. T. Tank in April. But there are only two possible theses: if their volumes, valves, and vents are equivalent, either the spheritank or the cubitank can be emptied more quickly. How do you reckon?"

"The classical perfection of the sphere prevails," answered Cal Klater. "Its discharge time in seconds is $1.6kVD^{-0.5}$, where $1/k = C_dA\sqrt{2g}$, and V is the volume, D the diameter of the tank, and C_dA the effective area of the orifice. The time for the cube is $2kVL^{-0.5}$, where L is its edge. For equal volumes, $D = L\sqrt[3]{6/\pi}$, so the discharge time for the cubitank will be $1.25\sqrt[6]{\pi/6} = 1.39$ times as long as for the spheritank."

"That ratio checks my figures," chirped Joe Kerr, "789 seconds for the cubitank against 566 for the spheritank. Tell your old cynic that two scholars agree."

"Make it three!" yelled another, brandishing a slipstick.

"While I just wonder if the cynic isn't half right after all," mused John Prior. "Cal and Joe reckoned which tank will empty first. Didn't you ask 'which can be emptied more quickly?'"

"Precisely."

"And artfully, for we can empty the cubitank more quickly by tipping it up on one edge. Lend me that slipstick and 15 seconds. * * * There. Its emptying time becomes $\frac{8}{3}k\sqrt[4]{2}(\sqrt{2}-1)VL^{-0.5}$, or 66% of the erect cubitank—say 92% of the time for the spheritank. Since you can't tip the spheritank, the cubitank has an edge in more ways than one. Tipping up on a corner should be even better."

"That makes you twice as right as the cynic. On one corner, the cubitank's discharge time reduces to $1.6k\sqrt[4]{3}(3\sqrt{3} - 4\sqrt{2} + 1)VL^{-0.5}$, or 448 seconds. That's the way the tank was built in Tank's town.

"The experts all agreed that the quickest emptier-outer would have been a standpipe, 10,000 ft high with constant section equal to the orifice—just a pipe on end. It would empty in less than 25 seconds, but imagine trying to get past priorities with a quintuple super-extra-heavy 4.28-in. ordnance-steel pipe."

"Former Guest Professor Richard Jenney is present for a return engagement. He says he has another as tough as that Hollywood bathroom. We're listening, Dick."

"Then here goes, Noah. Our mutual friend, Ken Bridgewater, recently built a military-access road—straight as a swig of Duggan's Dew. Over Dog Creek he stretched a 350-ft bridge, and another half as long over Pup Creek.

"His final report included a panorama taken from a camera station which turned out to be as far from the highway as the distance between the two bridges. In the picture, the Pup Creek Bridge scaled the same length as the Dog Creek Bridge, the scale being the maximum possible with that equality. How far were the bridges apart?"

"Thanks, Dick. That should engage the perspective of our bridge engineers until August."

(Prof. John C. Prior submitted the only "A" paper. Except for him and the Guest Professor, the above characters are fictional or anonymous.)

Brief Notes

THE fifteenth semi-annual meeting of the Eastern Photoelasticity Conference will be held on June 20 in Boston, Mass., at the University Club. All inquiries should be addressed to W. M. Murray, Room 1-321, Massachusetts Institute of Technology, Cambridge, Mass.

* * * *

ANNOUNCEMENT has been made of a new four-year undergraduate course in city planning, which will be offered by the Massachusetts Institute of Technology for the first time in 1942-1943. The program, which is under the direction of Prof. Frederick J. Adams, includes preparatory subjects in engineering and the natural and social sciences. The third and fourth-year courses will be primarily technical in character, with emphasis on the economic and administrative aspects and the working out of actual problems.

* * * *

SINCE February 1941, Pratt Institute, Brooklyn, N.Y., has offered courses in Aerial Bombardment Protection. The Institute's fourth course begins June 9. There is no charge for tuition as the course is sponsored and financed by the Government. Enrolment blanks are obtainable from, and returnable to William J. McGuinness, Assoc. M. Am. Soc. C.E., Coordinator, A.R.P. Program, Pratt Institute, 215 Ryerson St., Brooklyn, N.Y.

* * * *

SUMMER defense training courses are being offered by the Polytechnic Institute of Brooklyn, Department of Civil Engineering. Starting June 8, two nights a week for 15 weeks there will be a course in Airfield Engineering, one in Topographic Map Drafting, and one in Mechanics and Strength of Materials. For details, address the Department of Civil Engineering, Polytechnic Institute, Brooklyn, N.Y.

MORE THAN 100 technical papers and reports are scheduled for presentation at the Forty-fifth Annual Meeting of the American Society for Testing Materials to be held at the Chalfonte-Haddon Hall, Atlantic City, N.J., June 22–26. There will be more than 150 meetings of technical committees, and some 18 separate official technical sessions. Two outstanding technical features are the symposium on radiography, for which three sessions are scheduled, and the discussion on the solvent action of water vapor at high temperature and pressure. There will also be papers on ferrous and non-ferrous metals; on cement, concrete, and mortars; and on many other subjects.

Government Requests Pictures

THE COORDINATOR of Information wishes to get in contact with all engineers who are amateur photographers and who may have motion pictures or still photographs covering foreign countries, made within the past twenty years. If so, this agency would like to borrow such illustrations for inspection and possible confidential duplication for Government purposes.

Field notes, diaries, or record books bearing annotations would be of great importance. Postal cards and other purchased prints of foreign countries are also desired.

A postal card directed to the Pictorial Records Section, Coordinator of Information, 25th and E Streets, N.W., Washington, D.C., will suffice to give the preliminary notice that there is such material. A questionnaire will then be sent and arrangements made thereafter for examination at the place where this material can be seen; or the owner may be asked to send it to Washington. Any shipping charges involved would be paid by the Government.

In this manner engineers will be directly advancing their country's war effort. It is understood that all films and photographs would be loaned for the exclusive use of the Government, and not for any commercial showing or publication. This material would be returned in good condition and without undue delay after it had served the purposes of the Coordinator of Information.

In particular, owners of such material are asked not to send any films or photographs until they are requested to do so.

NEWS OF ENGINEERS

Personal Items About Society Members

A. D. ALEXIS, commander, CEC, U.S. Navy, has been ordered to the West Coast and will be stationed at the Staff Headquarters of the Thirteenth Naval District, Seattle, Wash. Until recently he was officer in charge of construction at the Naval Supply Depot and Dry Dock at Bayonne, N.J.

A. ANDREW BOEMI has resigned his post with the New York City Planning Com-

mission in order to join the staff of the Bureau of the Budget in Washington, D.C. He will serve in the capacity of administrative consultant.

MURRAY BLANCHARD, who is in the U.S. Engineer Department, has been transferred from the District Engineer's Office at St. Paul, Minn., to Sault Ste. Marie, Mich., where he will be employed on the new lock construction. It was just fifty years ago that Mr. Blanchard first went to Sault Ste. Marie—that time as rodman on the construction of the second, or Poe, Lock.

HARLEY G. OVERHOLT is now maintenance engineer for the Twin Cities Ordnance Plant at New Brighton, Minn., the position representing a promotion from the post of assistant works and construction engineer.

JAMES N. PEASE, consulting engineer of Charlotte, N.C., has been called to active duty with the Corps of Engineers, U.S. Army, and is stationed at Fort Bragg, N.C. He has the rank of colonel.

JOHN E. WILEY, formerly engineer-secretary of the Wyoming Associated General Contractors, with headquarters at Cheyenne, has been commissioned a captain in the Engineer Corps of the U.S. Army.

GEORGE G. HAYDEN is now a lieutenant (jg) in the Civil Engineering Corps of the U.S. Navy, assigned to the Department of Buildings and Grounds at the U.S. Naval Academy, Annapolis, Md. Until recently he was office engineer for the Portland Cement Association in New York City.

DUFF A. ABRAMS, New York City consultant, has been awarded the Frank P. Brown Medal of the Franklin Institute, Philadelphia. The award was made for "his work in discovery of a fundamental design basis for concrete and reinforced-concrete mixtures."

HAYWOOD G. DEWEY, JR., has reported for active duty as first lieutenant in the Field Artillery at Camp Roberts, Calif. Last fall Mr. Dewey returned to his position as assistant engineer for the U.S. Bureau of Reclamation at Denver after a year spent in hydraulic research in various parts of the country as Freeman Traveling Scholar for 1940–1941.

NED L. ASHTON has been granted a leave of absence from his position as chief designer for Howard-Needles-Tammen and Bergendoff at Kansas City, Mo., in order to do defense work. At present he is structural steel designer for the Austin Company at the Oklahoma City (Okla.) Aircraft Assembly Plant.

SAMUEL J. LORING, research engineer for the Vought-Sikorsky Company, at Stratford, Conn., is the recipient of the Wright Brothers' Medal, which was awarded by the aeronautical section of the Society of Automotive Engineers. Mr. Loring received the award for his paper entitled "Outline of a General Approach to the Flutter Problem," which was presented at the annual meeting of the S.A.E. in January 1941.

CHARLES UNDERHILL POWELL, since 1915 engineer in charge of the Queens Topographical Bureau, has announced that he will retire. Mr. Powell, who has been in the service of the city since 1898, had his first engineering assignments on Brooklyn Bridge and early subway construction work.

T. B. LARKIN, colonel, Corps of Engineers, U.S. Army, has been relieved of duties at Balboa Heights, C.Z., where he was supervising engineer of the Special Engineering Division of the Panama Canal, and assigned to the Commanding General of the air forces at Washington, D.C.

NICHOLAS H. HECK was recently promoted from the position of chief of the Division of Terrestrial Magnetism of the U.S. Coast and Geodetic Survey to that of assistant to the director of the Survey. Captain Heck will devote his attention to scientific and technical matters. He will be succeeded by COMDR. O. W. SWAINSON, formerly assistant chief, who will have the title of chief of the Division of Geomagnetism and Seismology. COMDR. H. A. COTTON will be made assistant to Commander Swainson.

HENRY T. LOFFT, who is on the staff of the TVA, has been appointed construction engineer on the South Holston and Watuga Dam projects, with headquarters at Bristol, Tenn.

JOHN VERNON OTTER is now project manager on the construction of a new defense plant near Pocatello, Idaho.

BEVERLY C. DUNN, colonel, Corps of Engineers, U.S. Army, has been transferred to New York City from Seattle, Wash., where he was district engineer.

DECEASED

ARTHUR BRENNAN (Jun. '36) of Anchorage, Ky., was killed in an automobile accident near Galveston, Tex., on April 1, 1942. Mr. Brennan, who was 27, was for several years with the U.S. Engineer Department at Louisville, Ky.

HARRY CHARLES CHILD (M. '30) consulting engineer of Sayre, Pa., died on March 5, 1942, at the age of 55. At one time Mr. Child was assistant engineer for the New York City Public Service Commission, and he had been structural designer for Stone and Webster. Later he maintained an engineering and architectural practice at Sayre.

CHARLES STRATTON DAVIS (M. '05) consulting engineer of Pittsburgh, Pa., died at his home in that city on January 2, 1942, at the age of 75. Beginning in 1889, Mr. Davis was for some years connected with the Massillon Bridge Company, of Toledo, Ohio—from 1893 on as chief engineer. Before establishing his consulting practice in Pittsburgh he was structural engineer for the Pennsylvania Company at Detroit, Mich.

ARTHUR GREEN (Assoc. M. '29) civil engineer of Bristol, Tenn., died there on April 6, 1942. Mr. Green, who was 52, went to Bristol in 1924 to become city engineer. From 1931 to 1937 he served the city as commissioner of streets and public improvements, his term of office being marked by many municipal improvements. He helped obtain for Bristol the first CWA project in the nation—cleaning and widening the Beaver Creek channel. Since 1937 he had maintained a consulting practice.

WILLARD LIVERMORE GORTON (Assoc. M. '10) consulting engineer of Boise, Idaho, died there on March 25, 1942, at the age of 60. Early in his career (1911 to 1915) Mr. Gorton was chief irrigation and design engineer for the Philippine Department of Public Works. After serving as captain of engineers in the World War, he became chief engineer of the Idaho Public Utilities Commission. Later he was consulting engineer on Mexican irrigation projects, and from 1930 to 1933 served in a similar capacity in Turkestan. From the latter year until his retirement in 1941 he was consultant for the Boise Water Corporation.

ALAN GORDON GUTTERIDGE (M. '37) consulting engineer of Melbourne, Australia, died on February 21, 1942, at the age of 50. A native of Australia, Mr. Gutteridge was educated in the United States—at Harvard. After four years (1914 to 1918) with the Royal Canadian Regiment, he returned to Australia where he was, successively, assistant engineer for the Melbourne Harbour Trust and chief engineer for the Commonwealth Department of Health. For many years he maintained a consulting practice, and since 1939 had been a principal in the firm of A. Gordon Gutteridge, Haskins and Davey.

STEPHEN SAINT JOHN MALVEN (Jun. '37) of San Antonio, Tex., died in February 1942. Mr. Malven, who was 26, graduated from the Agricultural and Mechanical College of Texas in 1937. He then became junior base inspector for the Texas State Highway Department, remaining in that capacity for several years.

CHARLES MEADS (M. '10) New York City consultant, died on April 24, 1942, at the age of 72. Since 1905 Mr. Meads had been president of Charles Meads and Company, New York City engineering and contracting firm. Earlier in his career (1896 to 1904) he was superintendent of construction for R. H. Hood, engineer and contractor with offices in New York and Washington.

JOHN BURCHFIELD NEELY (M. '19) civil engineer of St. Louis, Mo., died recently. Mr. Neely, who was 58, was for a number of years chief engineer for the Missouri Bridge and Iron Company, at St. Louis. Earlier in his career (1908 to 1922) he held a similar position with the Kansas City (Mo.) Bridge Company in charge of design, estimates, field construction, and cost data.

DONALD ORELUP NELSON (Assoc. M. '26) since 1940 chief engineer for the Guy F. Atkinson Company on the construction of a naval operating base at Long Beach,

Calif., died recently. He was 43. From 1922 to 1925 and, again, from 1926 to 1931 he was with the Truscon Steel Company at Portland, Ore. He maintained a consulting practice from 1931 to 1933, and from 1934 to 1939 was with the Mason Walsh Atkinson Kier Company on the construction of the Grand Coulee Dam—first as structural engineer and then as assistant chief engineer.

EDWARD WILLIAM ROBINSON (Assoc. M. '08) president of Construction Management, Inc., of New York City, died at his home at St. James, L.I., on May 5, 1942, at the age of 68. From 1910 to 1917 Mr. Robinson was vice-president of the New York building construction firm, Ruggles and Robinson, and from 1920 to 1935 vice-president and general manager of the Triest Construction Company. In the latter year he became connected with the New York consulting firm of Frederic R. Harris, Inc., and thereafter was made president of Construction Management, Inc., an affiliate of the foregoing firm. During the first World War Mr. Robinson served in the Corps of Engineers with the rank of major.

GEORGE HENRY SAGER, JR. (M. '36) for the past two years engineer in charge for Ford, Bacon, and Davis, Inc., at Galveston, Tex., died on April 23, 1942. Mr. Sager, who was 47, was formerly a resident of Louisville, Ky., and had been executive director of the Louisville Municipal Housing Commission. He had also been Kentucky state engineer for the Public Works Administration and, at one time, was resident engineer for Ford, Bacon and Davis at Monroe, La.

BENJAMIN FRANKLIN TAYLOR (M. '30) senior highway engineer for the Public Roads Administration at Kansas City, Mo., died there on April 18, 1942. He was 59. In 1919 Mr. Taylor became connected with the Public Roads Administration (then the U.S. Bureau of Public Roads), and he had been senior highway engineer since 1928. At the outset of his career he was in the New York State Highway Department.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From April 10 to May 9, 1942, Inclusive

ADDITIONS TO MEMBERSHIP

AGNEW, DAVID REED (M. '42), Vice-Pres., Asheville Cont. Co., Asheville, N.C.

ALLISON, JOHN ANDREW (Jun. '41), 1st Lt., Corps of Engrs., U.S. Army, Asst. Div. Engr., 105th Engr. Battalion, 30th Division, Fort Jackson, S.C.

BAUWENS, GEORGE OTTO PAUL (Assoc. M. '42), Prof., Civ. Eng., Univ. of Southern California, University Park (Res., 10294 Cresta Drive, Los Angeles), Calif.

BLAKELY, MATTHEW LOUIS (Jun. '41), With Boeing Aircraft Co. (Res., 4800 Fremont Ave., Apt. 108), Seattle, Wash.

BLASER, WILLIAM EDWARD (M. '42), Deputy County Engr., County Engrs. Office, 1926 Standard Bldg., Cleveland, Ohio.

BROHAUGH, RICHARD GEORGE (Jun. '41), Senior Eng. Aide, Special Eng. Div., The Panama Canal, Diablo Heights, Canal Zone.

BUTRICO, FRANK ANTHONY (Jun. '41), Junior Naval Archt., Navy Yard (Res., 311 South 13th St.), Philadelphia, Pa.

CHING, QUAN YUEN (Assoc. M. '42), 2d Lt., Quartermaster Corps, U.S. Army, Army Post Office 954, Care, Postmaster, San Francisco, Calif. (Res., 3941 Maunaloa Ave., Honolulu, Hawaii.)

CHRISTENSEN, WALTER JUNIOR (Jun. '41), With Boeing Aircraft Co. (Res., 7615 Sand Point Way), Seattle, Wash.

COBAUGH, LEON RODNEY (Jun. '41), 2d Lt., Quartermaster Corps, U.S. Army, Company E, 10th Quartermaster Training Regiment, Camp Lee, Va.

COYNE, JOHN CHARLES (Jun. '41), 2d Lt., U.S. Army, 304th Field Artillery Battalion, Fort Jackson, S.C.

CLAYTON, LESLIE ALLISON (Jun. '41), Detailer, Am. Bridge Co., Ambridge (Res., Mount Sewickley Camp Ground, Sewickley), Pa.

DANBERG, ABRAHAM (Jun. '41), Civ. Engr. and Naval Archt., U.S.N., Navy Yard, Boston (Res., 9 Duke St., Mattapan), Mass.

DAVES, JOEL THOMAS (Assoc. M. '42), Sales Engr., Tennessee Coal, Iron & R.R. Co., 1310 Brown Marx Bldg., Birmingham, Ala.

FALLON, RICHARD GORDON (Jun. '42), With U.S. Army, 100–45 One hundred and ninety-fifth St., Hollis, N.Y.

FOX, MILO PITCHER (M. '42), Col., Corps of Engrs., U.S. Army, Secy., Mississippi River Comm., Vicksburg, Miss.

GESSLER, AXEL BERNARD, JR. (Jun. '41), Junior Engr., U.S. Engr. Dept., Union Guardian Bldg., Detroit, Mich. (Res., 4880 East 84th St. Cleveland, Ohio.)

GOUDEAU, MORGAN JEFFERSON, JR. (Assoc. M. '42), Civ. Engr., Opelousas, La.

GROSTICK, NORMAN LARSEN (Jun. '41), Junior Engr., U.S. Engr. Office, 700 Union Guardian Bldg., Detroit (Res., 421 East Clinton St., Howell), Mich.

HARDESTY, EGBERT RAILEY (Jun. '42), With Waddell & Hardesty, 101 Park Ave., New York (Res., Chatsworth Gardens Apartments, Larchmont), N.Y.

ITTER, CHARLES JUSTUS (M. '42), Engr., Design, Bureau of Water Works & Supply, 207 South Broadway, Los Angeles, Calif.

JACKSON, WILLIAM COYT (Assoc. M. '42), Designing Engr., Krueger & Clark, 71 Santa Plaza (Res., 116 West Manhattan Ave.), Santa Fe, N.Mex.

JEPSON, JOHN CLAUS (Jun. '42), Bridge Draftsman, State Highway Dept., Transportation Bldg. (Res., 1825 Water St.), Olympia, Wash.

KUO, HSUAN (Jun. '42), 301 College Ave., Ithaca, N.Y.

LANGFITT, LYLE EDGAR (M. '42), Asst. Estimator, Am. Viscose Corp., Nitro (Res., 820 Moore Ave., Dunbar), W. Va.

LOCHAK, BORIS (M. '42), Structural Engr., Gibbs & Hill, Inc., Pennsylvania Station Bldg. (Res., 102 West 80th St.), New York, N.Y.

LYNCH, HOWARD POYER (Jun. '41), 1065 East 31st St., Brooklyn, N.Y.

MCGREW, FINLEY OLIVER, JR. (Assoc. M. '42), Associate Engr., U.S. Engrs., Fisher Bldg. (Res., 3525 North East 27th Ave.), Portland, Ore.

MACAULAY, JAMES EARL (Assoc. M. '41), Lt., U.S. Coast Guard (R), 1300 Custom House, Boston (Res., 1 Marion St., Malden), Mass.

MONTOOTH, MARVIN RICHARD (Jun. '41), 2d Lt., U.S. Army, 92 South 5th St., San Jose, Calif.

MOORE, CHARLES SCOTT (Jun. '41), Civ. Engr., W. L. Huber & E. M. Knapik, 1 Montgomery, San Francisco (Res., 1625 Buena Ave., Berkeley), Calif.

MULLER, JOHN WILLIAM (Jun. '42), Junior Engr., P-1, Municipal Eng. Div., The Panama Canal, Balboa Heights, Canal Zone.

PARKER, THEODORE HAROLD (Jun. '41), Junior Engr., U.S. Engr. Office, 751 South Figueroa (Res., 1316 South Western Ave.), Los Angeles, Calif.

PAUL, CHARLES EUGENE (M. '42), Engr., U.S. Army Engrs., New Federal Bldg., Pittsburgh (Res., 104 Tioga St., Johnstown), Pa.

SCHAFFNER, CHARLES ETZEL (Jun. '41), Instr., Civ. Eng. Dept., Cooper Union, Cooper Sq., New York (Res., 71-05 Sixty-eighth St., Glendale), N.Y.

SCHLUP, TRUMAN BANKSON (Assoc. M. '42), City Engr., City Hall, Kansas City, Kans.

SCHNURR, FRANCIS MAURICE (Jun. '41), 603 West Washington St., Sandusky, Ohio.

SENOUR, CHARLES (M. '42), Head Engr., Mississippi River Comm., Box 80, Vicksburg, Miss.

SEYMOUR, HAROLD JAMES (Assoc. M. '42), Asst. City Engr., City Hall, Elizabeth, N.J.

SHIPMAN, ROY MARVIN (Jun. '42), Structural Designer, Arundel & Consolidated, Box 3944, Santurce, Puerto Rico.

SMITH, ROY THOMAS, JR. (Jun. '41), Care, J. F. Johnson, Box 479, Austin, Tex.

STAHL, HARRY HERMAN (M. '42), Asst. Chf. Engr., Belmont Iron Works, 2215 Washington Ave., Philadelphia, Pa.

STONE, CLYDE CALLAHAN (Jun. '41), Ensign, U.S.N.R., Navy Yard (Res., 6018 Drexel Rd.), Philadelphia, Pa.

TAYLOR, ALBERT DAVIS (M. '42), Landscape Archt. and Site Engr., 4614 Prospect Ave., Cleveland, Ohio.

THOMPSON, VIRGINIA (Jun. '41), Eng. Aide, U.S. Waterways Experiment Station (Res., 1100 Crawford), Vicksburg, Miss.

WADSWORTH, THOMAS JERALD (Jun. '41), Ensign, U.S.N., 1465 West 33d St., Apt. 306, Minneapolis, Minn.

WALKER, CARL CLAYTON (M. '42), Engr., The Jennings-Lawrence Co., 538 Rowlands Bldg. (Res., 1826 West 1st Ave.), Columbus, Ohio.

WEBBER, JOSEPH CARL (Assoc. M. '42), Office and Design Engr., City of Toledo, 565 Erie St., Toledo, Ohio.

WEESNER, GEORGE WOOD (Jun. '41), Shipfitter, Nashville Bridge Co., Sparkman St. Bridge (Res., Woodmont Blvd.), Nashville, Tenn.

YOHALEM, MARTIN JUSTIN (Jun. '41), Care, Joint Highway Research Project, Purdue Univ., West Lafayette, Ind.

MEMBERSHIP TRANSFERS

BAKER, WILFRED HARMON (Jun. '36; Assoc. M. '42), Asst. Prof., Civ. Eng., West Virginia Univ., Morgantown, W.Va.

BERRIGAN, PAUL DUNN (Assoc. M. '40; M. '42), Lt. Col., Corps of Engrs., U.S. Army, 1619 Cotton Exchange Bldg., Dallas, Tex.

BURNETT, DOUGLAS HAROLD (Jun. '31; Assoc. M. '42), Industrial Engr., Standard Oil Co. of California, 225 Bush St., Room 1029, San Francisco, Calif.

CATTON, MILES DEWEY (Assoc. M. '28; M. '42), Mgr., Soil Cement Bureau, Portland Cement Assn., 33 West Grand Ave. (Res., 7341 North Seeley Ave.), Chicago, Ill.

CRANLEY, EDWARD PATRICK (Jun. '35; Assoc. M. '42), Supt. of Maintenance, Archt.—Board of Education, 228 North La Salle St., Room 510 (Res., 5044 North Kilbourn Ave.), Chicago, Ill.

DOWLING, LOUIS EARL, JR. (Jun. '36; Assoc. M. '41), Associate Engr. (Structural), U.S.N., Bureau of Yards and Docks, Navy Bldg. (Res., 4320 Fourth St., N.W.), Washington, D.C.

ENKE, GLENN LAVINE (Jun. '28; Assoc. M. '42), Asst. Chf. Engr., Utah-Pomeroy-Morrison, Box 197, Provo, Utah.

GOODWIN, JAMES WILLIAM (Assoc. M. '36; M. '42), Cons. Engr. (J. W. Goodwin Eng. Co.), 344 Martin Bldg., Birmingham, Ala.

GREER, DAVID MCKAY (Jun. '39; Assoc. M. '42), Asst. Engr., U.S. Engr. Office, M. and M. Bldg. (Res., 1731 Marshall), Houston, Tex.

HESELTON, FRANK RICHMOND (Jun. '40; Assoc. M. '42), Asst. Engr., U.S. Engr. Office, 60 South Beaver St., York, Pa.

HIAT, DAVID (Jun. '39; Assoc. M. '42), Architectural Engr., Eggers, Higgins, Wilcox & Erickson, 542 Fifth Ave. (Res., 34 Metropolitan Oval), New York, N.Y.

HILL, JACOB ERNEST (Jun. '33; Assoc. M. '42), Associate Engr., U.S. Bureau of Reclamation, Box 66, Colville, Wash.

HYDE, GEORGE EMMONS (Jun. '34; Assoc. M. '42), Asst. Hydr. Engr., Bonneville Hydr. Laboratory, U.S. Engr. Office, Bonneville, Ore.

LOCRAFT, BERNARD FRANCIS (Assoc. M. '35; M. '42), (Berrall & Locraft), 615 Colorado Bldg., Washington, D.C. (Res., 2900 Daniel Rd., Chevy Chase, Md.)

MAIER, FRANZ JOSEPH (Jun. '40; Assoc. M. '42), Associate Public Health Engr., U.S. Public Health Service, Sub-Treasury Bldg., New York (Res., 7035 Broadway, Jackson Heights), N.Y.

MARSTON, GEORGE ANDREWS (Jun. '30; Assoc. M. '42), Asst. Prof. of Eng., Massachusetts State College (Res., 28 Kellogg Ave.), Amherst, Mass.

MURER, ELDRED BEVERLY (Jun. '30; Assoc. M. '42), Cons. Engr. (A. Y. Taylor & Co.), 2 South Central Ave., Clayton, Mo.

NUBAR, YVES (Jun. '28; Assoc. M. '31; M. '42), Cons. Engr., 152 West 42d St. (Res., 374 Wadsworth Ave., Apt. 4E), New York, N.Y.

PRATT, ALMA (Jun. '35; Assoc. M. '42), Road Engr., U.S. Indian Service, Fort Duchesne, Utah.

PRICHARD, ROBERT LEO (Jun. '38; Assoc. M. '42), Civ. Engr. (P-4), Corps of Engrs., War Dept., Office of Dist. Engr., Corozal, Canal Zone.

RUDDY, JOHN MICHAEL (Jun. '32; Assoc. M. '42), Engr. Insp., Grade 4, Board of Water Supply, Neversink (Res., 109 Carrier St., Liberty), N.Y.

SONNE, JULIUS ASA (Jun. '32; Assoc. M. '42), Lt. (jg), CEC, U.S.N.R., 2242 Thirty-fourth Ave., San Francisco, Calif.

SORING, ARTHUR RANDOLPH (Jun. '31; Assoc. M. '42), Engr., U.S. Engrs., Box 2240, Honolulu, Hawaii.

STUART, WILBUR TENNANT (Jun. '39; Assoc. M. '42), Asst. Hydr. Engr., Ground Water Div., U.S. Geological Survey, Box 47 (Res., 1103 Sixth Ave.), Safford, Ariz.

SWEETON, ARTHUR WATSON, 3D. (Jun. '35; Assoc. M. '42), Senior Asst. Engr., Dept. of Eng., Bureau of Public Works, 550 Main St. (Res., 270 Edgewood St.), Hartford, Conn.

TAYLOR, JAMES DONALD (Jun. '36; Assoc. M. '42), Office Asst. to Vice-Pres. of Operations; G. N. Ry., Great Northern Bldg. (Res., 942 Osceola Ave.), St. Paul, Minn.

TOTAL MEMBERSHIP AS OF MAY 9, 1942

Members	5,761
Associate Members	6,897
Corporate Members	12,658
Honorary Members	35
Juniors	4,955
Affiliates	69
Fellows	1
Total	17,718

VEIGEL, LOUIS WALTER (Jun. '38; Assoc. M. '42), Cons. Engr., Courthouse, Dickinson, N.Dak.

WAGNER, LAWRENCE FREDERICK (Jun. '31; Assoc. M. '42), Engr. and Land Surv., Harry C. Shinn, 9 Allen St., Toms River, N.J.

YOUNG, DANA (Jun. '26; Assoc. M. '35; M. '42), Prof., Applied Mechanics, The Univ. of Texas, Austin, Tex.

REINSTATEMENTS

ALBERMAN, ERNEST SAMUEL, Assoc. M., reinstated May 4, 1942.

BABCOCK, CHARLES IRVING, Assoc. M., reinstated Apr. 13, 1942.

BARNES, ALFRED EDWARD, Assoc. M., reinstated Apr. 23, 1942.

BRIGGS, JAMES HARVEY, Affiliate, reinstated Apr. 10, 1942.

FALSTAD, GUNNAR, Assoc. M., reinstated Apr. 22, 1942.

HETTMAN, FREDERICK JACOB, M., readmitted May 1, 1942.

HARLEY, GEORGE FOSTER, M., readmitted May 1, 1942.

LEUE, CONRAD FERDINAND, Assoc. M., reinstated Apr. 20, 1942.

PELLER, JOSEPH PAUL, Assoc. M., reinstated Apr. 28, 1942.

SMITH, ROY ELMER, Assoc. M., reinstated May 4, 1942.

STUBER, HARRY WILLIAM, Assoc. M., readmitted May 1, 1942.

RESIGNATIONS

ARNOLD, RALPH RAYMOND, M., resigned Apr. 22, 1942.

TAYLOR, HENRY GEORGE, M., resigned Dec. 31, 1941.

WENSTRAND, RALPH THEODORE, Assoc. M., resigned Apr. 23, 1942.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment from Members to Board of Direction

JUNE 1942 NUMBER 6

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

GRADE	GENERAL REQUIREMENT	AGE	LENGTH OF ACTIVE PRACTICE	RESPONSIBLE CHARGE OF WORK
Member	Qualified to design as well as to direct important work	35 years	12 years	5 years RCM*
Associate Member	Qualified to direct work	27 years	8 years	1 year RCA*
Junior	Qualified for sub-professional work	20 years	4 years	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years	5 years RCM*

* In the following list RCA (responsible charge—Associate Member standard) denotes years of responsible charge of work as principal or subordinate, and RCM (responsible charge—Member standard) denotes years of responsible charge of IMPORTANT work, i. e., work of considerable magnitude or considerable complexity.

APPLYING FOR MEMBER

ALLEN, JAMES HALE (Assoc. M.), Philadelphia, Pa. (Age 44) (Claims RCA 6.6 RCM 9.8) March 1937 to date Chf. Engr., Interstate Comm. on Delaware River Basin.

ANDERSON, VICTOR CHARLES (Assoc. M.), Little Rock, Ark. (Age 40) (Claims RCA 1.5 RCM 16.7) Feb. 1931 to date member of firms, Anderson & Knoop, and Capital Steel Co.

BICKEL, JOHN OTTO (Assoc. M.), New York City. (Age 45) (Claims RCA 4.0 RCM 8.9) Jan. 1941 to date Engr.-in-charge, Elec. and Mech. Dept., Frederic R. Harris, Inc.; previously Associate Engr., Parsons, Klapp, Brinckerhoff & Douglas, and Waddell & Hardesty.

CASAGRANDE, ARTHUR (Assoc. M.), Cambridge, Mass. (Age 39) (Claims RCA 7.0 RCM 5.0) Sept. 1932 to date at Harvard Univ., as Lecturer in soil mechanics, Asst. Prof., and (since Sept. 1940) Associate Prof., of Civ. Eng.

CASTLEMAN, FRANCIS LEE, JR. (Assoc. M.), Nashville, Tenn. (Age 39) (Claims RCA 3.4 RCM 7.2) Sept. 1935 to date at Vanderbilt Univ. as Instructor in, and Asst. Prof. of, Civ. Eng., and (since June 1938) Associate Prof. of Structural Eng.

CHERRY, JAMES LINTON (Assoc. M.), Glenside, Pa. (Age 37) (Claims RCA 2.0 RCM 9.7) 1934 to 1936 Associate and Profit Sharing Partner, 1936 to 1938 (Spare time and summers) Cons. Engr., and 1938 to date member of firm and Partner, H. A. Kuljian & Co., Cons. Engrs. & Constrs., Philadelphia, Pa.

COE, CLEVELAND BEACH (Assoc. M.), Knoxville, Tenn. (Age 49) (Claims RCA 9.9 RCM 6.1) Oct. 1940 to date Lt. Col., Corps of Engrs., U.S. Army, being Adjutant and Executive, 1st Mil. Area; previously with TVA as Prin. Eng. Draftsman, Asst. Highway Engr., and Associate Highway Engr., Office Design Sec.

CRENSHAW, JOHN WERNER, Wilmington, N.C. (Age 44) (Claims RCA 7.0 RCM 11.3) Oct. 1941 to date Associate San. Engr., Corps of Engrs., U.S. Army, Camp Davis, N.C.; previously Engr. and 1½ years member of firm, Kinsey Eng. Co., Pekin, Ill.

DIETER, FRANK LOUIS (Assoc. M.), Arlington, Va. (Age 38) (Claims RCA 9.9 RCM 7.3) March 1938 to date with Arlington County, Virginia, as County Planning Engr., Director of Planning, Secy., County Planning Comm.; previously Field Engr. with Wm. D. Darby; Designing Engr. with H. C. Webster, Cons. Engr., Milwaukee, Wis.